# THE FUTURE OF AVIATION

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TRANSLATED FROM THE FRENCH OF
JEAN DARGON

BY

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WITH A PREFACE BY M. ETIENNE LAMY
OF THE FRENCH ACADEMY

9 FULL-PAGE ILLUSTRATIONS, 2 MAPS, AND NUMEROUS DIAGRAMS

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## PREFACE

"PRE-WAR aviation was a sport; during war it has been a military weapon; after the war it will be one of the transport industries." In these pithy words, M. d'Aubigny, a French deputy and a recognised authority on aviation in France, has aptly summed up the past, present, and future of the most recent of the great industrial inventions.

The wishes of humanity have never been fettered by its inability to realise them immediately. The continual preoccupation due to these unattainable hopes stimulates man's mechanical genius, and all great inventions have begun by being dreams. To emulate the birds in their flight, and to add the starry depths to his domain, was one of man's earliest ambitions, and long defied his power. The ancient poets were the first to symbolise the recklessness and fall of venturesome ignorance by the legend of Icarus. They were succeeded by the poets of science, like Leonardo da Vinci, who designed a flying machine, but was unable to put it to practical test from lack of motive power. Later, when the science of chemistry had freed itself from the fallacies of the alchemists, the atmosphere was subjected to analysis in the laboratory; hydrogen was isolated from the other gases, and the lifting power of heated air was demonstrated by the natural phenomena observed in nature's laboratory.

Inflated with smoke or hydrogen gas, "lighter

than air" montgolfiers and balloons enabled man to ascend to hitherto unattainable altitudes before the end of the eighteenth century. But his power remained confined to rising in the air, and when floating in that medium he possessed no power to guide his machine, which remained at the mercy of the winds. It was not until the concluding years of the nineteenth century that the internal-combustion engine, whose invention had solved the problem of self-propelled road transport, was first tried for the purposes of flight.

At first the simplest plan seemed to consist in providing "lighter than air" machines with propellers which, actuated by the petrol engine, would drive the machine, sustained by its gas bag, through the air in the required direction. But it was found that the size of airships made them difficult to steer; moreover they were peculiarly sensible to the action of the wind, whether ahead or abeam, not only when in flight, but also when at rest. Moreover the flame of the engine in such close proximity to the inflammable hydrogen of the gas-bag constituted a source of great danger.

The future seemed to hold out no prospect of success to the airship, but by an apparent paradox the way was opened to the "heavier than air" machine.

A shell when leaving the mouth of a gun is maintained in the air because the force of the propellant behind it is greater than the force of gravity which tends to make it fall. Any flying machine driven by an engine of sufficient power becomes a projectile, and a projectile maintained in flight not by the initial and decreasing power of the propellant alone, but by the constantly renewed action of the propeller which drives it.

From that time onwards, the chief problem of aerial architecture consisted in giving the projectile the shape and structure best fitted to make it easy to steer, stable in a wind, slow to fall; but the essentials of the problem were independent of these experiments and could be solved apart from their success, since defects in shape and structure could be compensated by increasing the power of the engine.

The year 1897 saw the birth of the first "heavier than air" machine, by whose inventor, the Frenchman Ader, it was baptized by the (in French) definitive name of *Avion*.

The outbreak of war in 1914 surprised aviation in its early struggles; and if the machines were unprepared for war, the intelligence of their pilots was even more at fault. The brain is a creature of habit, just as much as the body; and as commanders only thought of reckoning with the existing weapons, they regarded aviation merely as a stunt. The least sceptical hoped to obtain the advantage of surprise by its aid, but even they did not count upon the regular co-operation of the "fifth arm." And as no one thought that aeroplanes would act in a regular, disciplined, self-sufficient manner, would decide the fate of battles—nay, the very result of the whole war—the insufficiency of equipment was in proportion to the small result which was expected from it.

The personnel of the French flying corps was neither well chosen nor homogeneous, its numbers were utterly insufficient, and the performances of the pilots were sometimes showy rather than useful. The fighting planes only numbered 138, of widely different types, among which the best climbers could only reach 10,000 feet with difficulty. The fastest of these machines could not do more

than 75 m.p.h., and those able to carry 300 kilos (660 lbs.) in addition to their pilot could scarcely attain 55 m.p.h. Owing to the rapid deterioration of the engines and to their frequent breakdowns, machines flying at this speed offered no sufficient margin of safety.

Peace had been the cradle of aviation, war proved an effective school. The necessity of beating the enemy in the contest for aerial supremacy obliged mechanics and aviators to strain every nerve to make both themselves and the new weapons more efficient in the field. Countless acts of heroic energy have given military aviation a magnificent prestige. The establishment of a properly graded hierarchy and the sense of *esprit de corps* have helped to check undisciplined hankering after purely personal glory, and slowly but surely an intelligent and logical distinction has been made between the three main functions of military planes.

For purposes of reconnaissance, to ascertain the positions, the movements, and the intentions of the enemy; to hinder and destroy his communications and preparations by aerial bombardment; to prevent his machines flying over our own lines and into our territory for observation or bombardment—this last being the work of the fighting patrol planes,—each of these three different objects called for a machine with special qualities, and in each case the improvements least necessary to its special purpose were sacrificed in favour of those which were most essential. For bombing machines, this was weight-carrying capacity; for observers, visibility and the capacity for flying at widely variable speeds; for fighting scouts, ascensional speed and rapidity of horizontal movement: since the machine with the

best chance of closing with its adversary, or escaping from it, is the one that can change altitude the quickest.

This transformation has been common to all belligerents; each following the same paths at increasing speed, and by its own progress accelerating that of its competitors. The French aviation budget in 1914 was only 47,000,000 frs. (less than £2,000,000); in 1917 it had attained the sum of 342,000,000 frs. (nearly £14,000,000). This outlay was intended to provide 5,000 fighting planes by April 1, 1918, but failed actually to build more than 3,500. This deficit of 35 per cent. was caused by defective methods of construction and organisation. But if we compare this defective result with the state of things before the war, and the 3,500 machines of 1918 with the 138 of 1914, this failure to attain our hopes is converted into a splendid advance on our past achievements.

And the improved quality of the machines themselves is even more important than their increase in numbers. Bombing planes can now carry two tons of explosives instead of the 6 cwt. of four years ago, and at a speed of 90 m.p.h., which is greater than that of the fastest pre-war machines. To-day speeds of over 150 m.p.h. have been attained, and chaser planes can climb to 5,000 metres in fifteen minutes. Moreover present-day machines are as superior to their ancestors in strength and stability as they are in point of speed; and the engines, the source of this power, show a like progress in solidity and reliability. Formerly the life of an aeroplane engine could be measured by hours; at present, 400 working hours is a moderate estimate of its duration. At a rate of 100–200 km. (62–125 miles)

p.h. this is equal to a flight mileage of 40–80,000 km. (25–50,000 miles) or once or twice round the globe.

Fourteen years only have elapsed since the Wrights' first and then unknown flights in America, eleven since their first public flights in France: few human inventions have made such wonderful strides in so short a time.

The mastery of the air acquired by our soldiers opens up vast possibilities, which are far too important to be confined to the battle-field, like Wright's first European machine flying at Auvours in 1908 confined within the limits of a military aerodrome. Wider horizons and greater destinies await it, and the present generation already feels the call. The horrible but necessary operation in which all the great democracies are engaged, in which all present joys have been sacrificed to safeguard the rights of future generations, forces them to accumulate ruin and slaughter. But their sufferings are equal to their determination to achieve victory, and to sustain the courage necessary to this great sacrifice the hopes of reconstruction are ever present to their minds, when the world will again be quickened by the services of peace, and ready to celebrate victories unstained by innocent blood.[1]

Human progress prior to the war was of a general character, and perhaps its most striking feature was the continual improvement and acceleration of all those methods of locomotion and communication which tend to render life more rapid. Steam engines, automobiles, telegraphs and telephones, the great inventions of the nineteenth century, have all become a necessary part of civilised existence, and have

[1] Written before the conclusion of the armistice.

caused its speed to increase correspondingly. Though unable to make life last longer, we have achieved the miracle of making it fuller; and the same lapse of time has acquired a greater value, since more energy, that is to say a greater number of joys and activities, can be compressed within a shorter space of time than formerly. As the world progresses, so does the pace increase. This haste is due to the knowledge of the briefness of our sojourn on this earth, and is thus an attempt to overtake the flight of time. This is why one form of power, namely speed, has obtained such a strong hold on our imaginations, and has become so universally popular owing to its resemblance to the fickle and restless genius of time.

To state that speeds of 250, even 300 kms., are now possible fails to convey a proper notion of the progress achieved. For to those vehicles which cannot leave the earth's surface, every rise and fall of the ground lengthens the distance to be covered, and these ascents and descents can only be avoided by detours which also increase the length of the journey. Though the sea offers a flat surface for travel, it is seldom possible to proceed from port to port in a straight line, for there are many capes to be doubled in the course of the voyage. And often it is more than a question of doubling them! A vessel proceeding from Colon to Panama must traverse the Atlantic as far as the Horn, and then the Pacific up to the isthmus, a voyage of over 12,000 miles, or half-way round the globe; although it is only forty miles as the crow flies between the two places.[1]

Generally free to proceed direct to their des-

[1] *Translator's note.*—M. Lamy appears to have forgotten that the Panama Canal has now been built some years.

tination, aircraft have a monopoly of the shortest routes. Even when crossing the highest mountains, the flight of an aeroplane does away with all sinuosities, for its course consists of two straight lines, straight from the ground to the highest point of its flight and then straight down again.

The cost as well as the duration of journeys will be reduced when commercial aviation has been organised. For the establishment of terrestrial routes entails two classes of expenses: the construction and maintenance of the permanent way, the building and running of the vehicles used. Aviation will substitute the countless highways of the air for the rare and costly routes by land. The only permanent structures required by an air line consist of a few landing grounds and air stations, with the necessary signposts or guiding marks to show the pilot his proper course. These expenses, compared with those necessary for the construction of a railway or a good road, are insignificant, and the operating expenses of the line will be almost limited to the initial cost of the aircraft employed, and that of their upkeep and repair.[1]

The element in which aircraft move, sometimes hostile, sometimes neutral, sometimes favourable to their flight, affords on the whole a steadier and less brutal resistance than either that of the waves beating against a ship's side or than the friction of the earth to the wheels of a vehicle. As soon as aeronautics have passed the stage of mere experiment, and have reached that of every-day use, the cost of machines is bound to fall as their production increases. For these reasons,

[1] *Translator's note.*—M. Lamy is perhaps unduly optimistic: he seems to have forgotten wages and the necessity for replacing worn-out aircraft, whose life is notoriously short.

it would seem that aerial locomotion, whether in private machines, or by public craft plying on regular routes, is destined to become the least costly of all forms of locomotion.

Speed and cheapness would not, however, be alone sufficient to attract the public. Public transport services, which will always remain the most important, require above all regularity and safety for their success. Unless able to guarantee regular times of departure and arrival, aerial transport lines will look in vain for goods and passengers. But aviation is subject to atmospheric laws and to aerial caprice. During part of the twenty-four hours we call a day, darkness prevents pilots from seeing their way or from landing with safety. Even during daylight the prevalence of fogs may deter the aviator from starting; and rain, which soaks and stiffens the canvas parts of the machine, hinders flying by increasing the weight of the vehicle and making it less manageable. Head winds, exceeding fifty miles an hour in speed, are almost impossible to contend against, and if blowing abeam they make steering a matter of great difficulty. But these obstacles to actual flying are not sufficient to compromise its great future. The steady and victorious progress achieved by all human inventions is a sufficient warrant for assuming that darkness will not always be an insurmountable obstacle to flight; and that fogs will not always prevent safe landings, nor rain always hamper machines in flight; and the constantly increasing power of engines will steadily lessen the proportion of gales against which aircraft struggle in vain.

For countries like France, where daylight lasts from eight to sixteen hours according to the

season, and where bad weather does not on an average prevent flying more than one day in ten, air services can even now be established with fairly regular time-tables.

But it is certain that only their safety will ensure their success. This constitutes the fundamental difference between civil and military aviation.

The latter is quite indifferent to considerations of safety. Nor is this due to the fact that the whole object of military aeroplane design, and the perfection it has achieved, consists in increasing the offensive power of the machines.

Fighting planes are designed above all with a view to being able to overtake their opponents from above and swoop down upon them; the efficiency of bombing machines depends almost entirely on their weight-carrying capacity; while reconnaissance scouts must be fast enough to avoid or escape from all hostile fighting planes. In all these cases, the qualities acquired entail the absence of dead weight as far as possible: in other words, their power depends on their lightness.

It follows that the designers have had one idea always before them: their constant aim has been to reduce the body structure to its narrowest limits, to use only the lightest materials available, to hollow out the form of the machine and make the fittings as slight as possible; in fact to economise weight by every possible means. But reduction of weight means loss of safety, the thin skeleton of the wings is scarcely able to resist the strain they have to bear, the propellers revolve on shafts of exceeding slenderness; and above all the engine, constituting the metallic portion of the plane, has been lightened to

such an extent that it is barely equal to its task of sustaining the bird of wood and canvas in the air, and driving it forward at the necessary speed. Nor is its frail structure spared in any way, but is exposed to the dangers of night flying, to violent gales, and to hazardous chance landings. Under the strain of these unequal contests, the machine frequently succumbs, betrayed by one or other of its weak points. To increase its mobility the reserves of fuel are cut down to a minimum, with the result that machines delayed by head winds or hampered by fog are often forced to land on unsuitable ground, with disastrous consequences. When the overdriven engine gives out, the pilot's only chance lies in a volplane descent if his altitude is sufficient, the ground favourable, and the wings strong enough to stand the strain. Should one of these fail him, he is doomed to fall like a stone. Aerial statistics read like a martyrology. But military aviators are not content to run the risk of these dangers, they court them deliberately. Their desideratum is an instrument of surprise, not designed for the accomplishment of ordinary tasks, but capable of the sublimest and most extraordinary feats; the perfect machine in their eyes is the one offering the greatest prospect of victory, and this perfection is not diminished because the chances of death from ordinary flying risks are thereby increased. Their heroic outlook counts the life of the combatant as naught in comparison with the efficiency of the weapon.

Nevertheless the lives of those who place the enemy's loss far before their own safety are too valuable to their country not to be protected against their own instincts. And the great need for their service has at length, and somewhat tardily, called forth a determination to reduce the

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risks they are called upon to run to the strictest minimum.

The sudden stoppage of the engine has always been the most frequent and most dangerous of these risks; and one remedy consists in fitting machines with two or more engines, each as powerful as a single motor and capable of sustaining the aeroplane by its own power, should the others fail. This naturally entails a corresponding increase in the total weight to be carried, but this increase is more than compensated by the gain in ascensional power. Since 1915 many machines have been fitted with two engines, and the means have been found of making every part sufficiently strong without any undue increase of weight, thus enabling machines to carry the necessary weight of bombs for efficient attack, and enough fuel for the longest flights. These increases in weight have gone hand in hand with greater strength, and have transformed aerial fleets by the creation of larger and stronger types of aircraft. The latest German models, for instance, are fitted with quadruple engines developing 1,000 h.p., and can carry four tons of explosives. In the struggle for supremacy and existence, military aviation has entered on a path which must be followed in the interests of commercial flying.

This latter requires no machines built only for trick flying, every part of whose structure (including their pilots) is in a state of unstable equilibrium; where safety depends almost entirely on the exceptional gifts of the man in charge, who is unable to fly more than a few hours at a time, owing to the intense strain inseparable from the complex nature of his numerous duties, which leave him no time to realise either his own fatigue or the discomforts of his task.

Civil aviation demands comfortable machines, able to remain in the air for long periods necessary to cross vast stretches of sea or desert, and able to carry passengers and goods in safety; all the parts of the aircraft must be chosen, assembled, and strengthened with the greatest care and thoroughness: this can scarcely be effected without an increase of weight. Passengers must find all the necessary comforts, and even luxuries, of travel; this needs space, and increased space means increased weight. Agility is essential to the art of fence. But the power of attaining great heights in the shortest time, of avoiding the impact of an opponent by lightning feints, looping the loops, or head dives, is in no wise essential to a good aerial liner or cargo craft. No time is lost by ascending somewhat slower, for such a vessel has no reason to fly at other than moderate altitudes which do not entail too great an ascent or descent at each stop. But if there is no necessity for stunts, and only ordinary manœuvring capacity at reasonable speeds is required, effective horizontal pace remaining the principal requirement, then heavy, stable types can be used without drawback. Every demand can be met by the adoption of a system of multiple, independent engines. Strictly speaking, two per machine should prove sufficient, for there is little probability of both failing in the course of a short stage. But if one engine stops, everything becomes dependent on the regularity of the other, and the fate of the machine and its passengers once more hangs upon the behaviour of a single motor. Commercial craft should not be exposed to such a risk; and the least that can be done is to offer them the same chances of safety which the latest types of military machine afford their pilots.

As the use of aerial routes for passenger and goods traffic becomes more general, it is fairly certain that machines will increase in size correspondingly; and by augmenting the power and the number of their engines, this problem will be solved satisfactorily. Their increased power will facilitate the construction of larger and stronger machines; the provision of several engines to each aeroplane will lessen, and even entirely eliminate, the danger of forced landings.

The subjects touched upon in this preface are dealt with in greater detail by the author of *The Future of Aviation*, whose identity may possibly be concealed under a pseudonym. If it is, however, impossible to verify his competence as an aviator, the persuasive quality of his work as an author and a prophet of the future prospects of flying is manifest. The book itself affords the best proof of a thorough, detailed, and accurate knowledge of the subject he treats. The aerial journeys he describes are wonderful, but convincing; and his relation to Jules Verne is like reality compared to a vivid dream. The plans for air routes that he sketches, with full and accurate details as to direction and time, succeed in convincing the intelligence; and more than one of these projects which read like fairy tales has already received the confirmation of actual realisation.

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# CONTENTS

## CHAPTER I

### PROGRESS IN AVIATION



## CHAPTER II

### AN AERIAL POSTAL SERVICE



## CHAPTER III

### AERIAL TOURISM



## CHAPTER IV

### COLONIAL AVIATION

## CHAPTER V

### ESTABLISHMENT OF AN AERIAL LINE BETWEEN ALGERIA AND WEST AFRICA



## CHAPTER VI

### MARITIME AERONAUTICS



## CHAPTER VII

### INTERNATIONAL AIR LINES OF THE FUTURE



## CHAPTER VIII

### REGULATION OF TRAFFIC IN THE AIR



## APPENDICES

# ILLUSTRATIONS



## LINE BLOCKS



## MAPS

THE

# FUTURE OF AVIATION

## CHAPTER I

### PROGRESS IN AVIATION

THERE are three main reasons which have contributed up to the present in preventing the aeroplane from being considered as a practical and reliable means of locomotion.

In the first place its lack of safety: for the enthusiasm which was aroused by the early flights was quickly followed by a certain distrust in respect of flying as a method of locomotion; and it must be admitted that such a feeling was not unnatural after the unduly frequent and fatal accidents that occurred in the opening stages of aviation, causing it to be regarded merely as an exciting and dangerous sport.

In the second place the very problematical regularity of aerial transport services: inasmuch as all kinds of aircraft have to struggle against the difficulties caused by contrary winds, eddies, air pockets, wind storms, and other atmospheric disturbances, not to mention rain, fogs, and darkness; in addition to which there is the constant danger of engine trouble, with its attendant consequences of unforeseen delay and dangerous

forced landings. Finally, the excessive cost of upkeep and operation, in combination with an insufficient carrying capacity—a few hundreds of pounds compared to the thousands of tons transportable by steamer or railway.

On the other hand, aviation offers many valuable advantages which should be made the most of:

(1) The possibility of proceeding from one place to another by the shortest route, *i.e.* in a straight line, avoiding the obstacles which hinder terrestrial locomotion of all kinds. The gains in time and distance which this faculty confers on aerial locomotion are incalculable.

(2) The abolition of permanent routes of communication, such as roads, railways, and canals, in favour of mere landing stations at the two extremities of an aerial route.

(3) Speed, which is continually on the increase, and with which no other means of transport can compete.

(4) The sporting interest afforded by flight.

Now one result of the great war has been to force aviation to develop in new directions. An imperative demand arose for aeroplanes of high speed, of the utmost handiness for fighter scouts, and of great carrying power for bombers (in both cases fitted with powerful and reliable engines). This led to the evolution of aeroplanes at once light and strong, speedy and reliable, thus possessing features of those most extreme qualities which from a technical point of view are almost irreconcilable.

On the other hand, the intensification of production on a large scale and in series has afforded the designers opportunities for manufacturing

machines of much greater perfection; the workmen have acquired the necessary skill for building new types of aeroplanes and motors, and the appropriate machinery for the production of the most complicated types has been laid down.

Finally, the art of flying, familiar only to a privileged few before the war, has become far more generalised. Numerous fliers have been trained, and their skill, endurance, and courage will help to encourage learners, and to spread the art of flying. It would seem therefore that with the cessation of hostilities, all those conditions will be present under which flying, emerging at last from the experimental stage, and from that of purely military utility, will be in a position to solve the problem of aerial navigation and to ensure the regular transport by air of passengers and goods. And it is the principal object of this work to prove that we have at length reached a stage in the development of aviation when it will become possible to utilise the services of aeroplanes in the interests of trade and commerce.

In order to understand the services which can be rendered by the new mode of locomotion, one must glance rapidly at the progress which has been made during the last few years: and the lessons to be learnt from a survey of past development cannot fail to inspire confidence in future progress.

AEROPLANES.—The majority of French aeroplanes in 1914 could be grouped under the two main types required for military work only.

(1) Monoplanes fitted with rotary engines, with a maximum speed of 75 m.p.h., which, owing to their difficulty of handling, could only be managed by exceptionally skilful fliers. Their maximum carrying capacity was one passenger,

and they could only reach a height of 10,000 ft. slowly and with difficulty: these were the existing scouts.

(2) Biplanes, usually fitted with rotary engines, and nicknamed "birdcages" by the monoplane fliers.

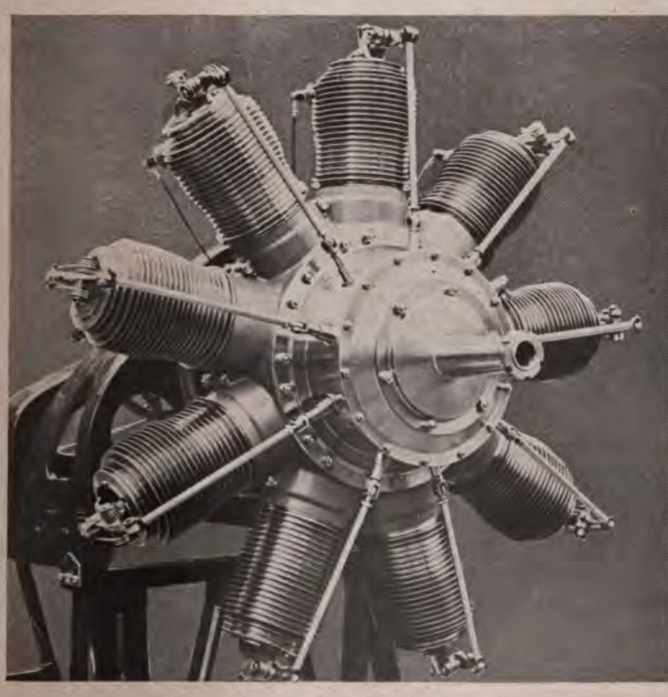
They possessed a carrying capacity of 660 lbs. at a speed of 50 m.p.h., and were then employed as observation machines and bombers.

Such machines, with a contrary wind of from 25 to 30 m.p.h., which is by no means rare at the higher altitudes, were condemned to practical immobility.

But under the pressure of war, and thanks to the stimulus of industrial competition against a well-equipped enemy, the theory and practice of aircraft construction have made enormous strides. Thanks to the unexpected resources which were placed at the disposal of technical experts, exceedingly complete and thorough experiments have been undertaken for the purpose of determining the laws of aerial resistance; the nature and best means of utilising the materials employed in aircraft construction, such as woods, coverings, and metals; and more exacting tests have been specified in order to obtain the guarantees necessary for the safety of our aviators.

Closer co-operation has taken place between designers and fliers, and their researches undertaken in common have been fertile in improvements: fuselages, struts, and all external parts have been stream-lined so as to offer less resistance to the air; numerous heavy and clumsy parts have been changed, lightened, or completely done away with; thanks to an improved choice of materials, they have become at once lighter and stronger; and owing to better designs and

A rotary engine undergoing a test on the trial bench. It revolves for several hours at given speeds; and its horse power and fuel consumption at each instant are carefully noted, as well as any incidents. Formerly, the unlucky engine was driven to death by the severe trials imposed, and its career often came to an untimely end while flying, to the great danger of machines and pilots.



A rotary engine.

more effective control of construction, the margin of safety has been increased while the weight of the whole structure was being lessened. Soon we shall be in a position to realise the value of the improvements which have been made in the details of the construction of fuselages, wings, and engines.

Lieutenant Gramont de Guiche has laid down the following principles for judging the characteristic qualities of an aeroplane. Speed; commercial carrying capacity; radius of flight; maximum altitude attainable. These different characteristics are closely connected according to mathematical formulæ which are now known; on any given type of machine, therefore, the alteration of any one of these characteristics will react upon all the remaining ones, and the consequent modifications can be foreseen.

It follows that if one of the qualities is increased, it must be at the expense of all the others; but this does not imply that aircraft construction is bound by cast-iron laws. That which is impossible at present may become possible in the future, since there are three factors governing the relation between the different characteristics of the aeroplane.

(1) The factor of safety which depends upon the method of construction.

(2) The weight per h.p. of the engine and its fuel consumption per hour (the type of propeller and its consequent efficiency are considered as part of the engine).

(3) The efficiency of the aeroplane.

It is clear that these three factors are constantly changing. Aircraft design is undergoing repeated improvements, the weight of the structure being lessened without any loss of strength.

With regard to engines, the improvement is even more striking, and both weight and fuel consumption have diminished greatly. Changes in structure have made them easier to fit into the fuselage, and this has increased aeroplane efficiency almost as much as improved wing forms, or the study of the air resistance of the stationary parts of the structure.

When a designer lays down the plans of the aeroplane that he proposes to build, he knows what type of construction he intends to make use of and what kind of engine he is going to fit. The efficiency of the machine remains the unknown quantity. Nevertheless it is possible to calculate these three factors provisionally when drawing the plans of the machine, and they should prove to be approximately correct. A detailed examination of such a plan is beyond our scope, but the following remarks are useful:

(1) Certain features are contradictory: *e.g.* horizontal speed and capacity for attaining great altitudes. Take a machine capable of rising to a height of 7,000 ft.; if the wing span is slightly reduced, the speed will be increased owing to the diminished resistance which it opposes to the air, but it will no longer be capable of attaining the same altitude. By continually reducing the wing surface, very fast machines can be built, similar to those which competed in the Gordon Bennett Cup of 1913, but their climbing power was very small, and they were only capable of carrying one person and one hour's supply of fuel.

(2) If it is specified that an aeroplane must be capable of a certain speed, climbing power, weight, and carrying capacity, there will be a maximum radius of action for a given engine power which must not be exceeded. The con-

struction of an aeroplane is subject to the same laws that are common to all kinds of structures.

When the dimensions and structure are in-increased, we know that the engine power required increases proportionately to the square of its head resistance, while the weight increases proportionally to the cube of its dimensions. To ensure a corresponding strength, therefore, the weight of the structure will increase out of all proportion to the increase in the area of the planes, until a point is reached when the whole fabric becomes too heavy to rise.

Starting from the light single-seater we thus arrive by successive increases in size and weight to a machine which is unable to rise; between these two extremes the change in the amount of useful load is continuous, and there exists one type able to carry a heavier load than others. But the machine with great carrying capacity will be an inferior climber.

ENGINES.—All pre-war aeroplane engines were liable to frequent breakdowns; their lifetime was in many cases not more than a few hours, and subject to continual accidents. Heat, cold, and atmospheric changes worked havoc with their frail constitutions, and great heights did not agree with them; engine trouble was to be expected at 5,000 ft. owing to defective working of the carburettor; and at 10,000 ft. they generally gave out; power decreased rapidly with increase in altitude.[1]

After having criticised the German water-cooled

[1] Owing to the decrease in atmospheric pressure as height increases, the gaseous mixture which supplies the motor becomes thinner and the power of the motor decreases as the machine rises; there is thus a maximum height for every machine; and a motor developing 200 h.p. at sea-level will only develop 150 at 7,000 ft. The latest types of carburettor have remedied this defect in a certain measure.

motors as being too heavy and cumbersome, we have at length adopted them likewise; and the latest types, with the improvements due to the incessant work of our engineers, combine great power (*e.g.* 200, 500, and 800 h.p.) with less weight and reduced fuel consumption.

These improvements have been accompanied by violent controversies, which still continue, between the defenders of the French type of rotary engine and the fixed water-cooled types, mainly of English or German design.

The former are lighter and take up less room; the latter necessitate the use of a radiator, etc., but are capable of developing greater power. Both types are still in use.[1]

This increase in the power of aeroplane engines, as well as in the number that can be mounted on one machine, constitutes an important step in the progress of aviation, and the capacity of aircraft has increased in the most encouraging manner.

In 1914 the French flying corps only possessed a few dozen machines able to carry from 4 to 6 cwt. at 60 m.p.h.; to-day there are in France several hundred machines, many of them able to fly at 150 m.p.h. (equal to 180 m.p.h. with a following wind of thirty miles).

Other types, heavier and slower, but with a

[1] The water-cooled system of design is more efficient than the air-cooled, where large cylinders are used; it ensures better combustion and consequently a diminished fuel consumption. Thus the extra weight of the radiator, the pipes and the water that must be carried, is compensated after a certain period of flight by the economy in the use of oil and petrol, as shown by the following table:

| | Petrol | | Oil | |
|---|---|---|---|---|
| | pints | gr. | pints | gr. |
| Average consumption per h.p. of air-cooled motors | 0·7 | 300 | 0·14 | 50 |
| Average consumption per h.p. of water-cooled motors | 0·5 | 230 | 0·05 | 18 |

greater carrying capacity, can fly with a useful load of 2 tons at over 100 m.p.h. and are capable of crossing the highest mountains in Europe (*i.e.* Mont Blanc, 15,000 ft.).

One of the best English machines has the following characteristics:[1]

| | |
|---|---|
| Engine power . . | 700 h.p. |
| Speed at 10,000 ft. . | 95 m.p.h. |
| Useful load . . | $2\frac{1}{2}$ tons |
| Full capacity . . | 11 hours flight |

Such a machine is thus able to fly 1,000 miles without a stop, has made successful trials at 7,000 ft. with twenty-two passengers, and has flown from Paris to Rome, in seven hours flying time, with five on board.

One of the best-known French constructors has made successful trials on a machine with four engines each of 200 h.p., and able to carry a useful load of $3\frac{1}{2}$ tons, equal to forty persons, at 85 m.p.h. Such a machine would be able to cross the Atlantic with a dozen passengers!

And several veritable flying vessels are being designed or actually built in France, England, Italy, and America; and if successful such aircraft will make the establishment of a regular trans-Atlantic air service a reality.

We are thus in a position to ask aircraft constructors to lay down regular "aerobuses," able to carry thirty passengers at about 90 m.p.h. and to fly 600 miles without a stop. They should also be able to build a commercial type of machine with a useful load of 6–8 tons at 90 m.p.h., and with a fuel consumption not exceeding $12\frac{1}{2}$ cwt. per hour.

[1] A later type is fitted with four engines developing 1,400 h.p., with a useful load of 8 tons.

And this is making no extravagant demand.

A few figures will suffice to demonstrate the rapid progress made in aircraft design during the last four years.

The wing surface of pre-war planes was on an average 20–40 square metres; it has been increased tenfold, since some of the most recent models have a wing surface exceeding 400 square metres.

The fuselage was mounted direct on to two or four wheels fitted with ordinary pneumatic tyres; these have been replaced by a proper undercarriage fitted with two wheels, shod with special pneumatic tyres.

The engine power has increased from 100 to 1,400 h.p.; the useful load from 1 cwt. to 8 tons; the speed from 75 to 150 m.p.h.; and the maximum height attainable from 10,000 ft. to 26,000 ft.

In the face of these striking results, and taking example from the development of railways, steamships, and automobiles, it is not saying too much to assert that aerial navigation is destined to revolutionise our present ideas on the subject of locomotion.

SAFETY.—Having ascertained the progress that has been made and the results achieved during the last few years in aircraft design, it is natural to inquire what are the conditions of safety and regularity under which aerial transport will take place.

Properly designed and well-built aircraft, which are now in a great majority, are, except when flown by unskilled or imprudent pilots, liable, generally speaking, only to one form of accidents, namely, those arising from forced landings on unsuitable ground; and such landings are generally due to engine trouble.

This risk would be absent if "heavier than air" machines were able to rise vertically and to alight without being obliged to run along the ground for a certain distance. But this problem has not yet been solved in a practical manner, and the few experiments with helicopters which have been made have not led to any definite result, and have been abandoned since the war.[1]

The speed necessary to sustain a machine in flight causes it to run a certain distance after touching the ground before it comes to rest; it would be a great advantage to diminish, if possible to eliminate completely, the length of this run, and designers have tried to achieve this object by building aeroplanes able to fly at widely variable speeds, *i.e.* flying as fast or as slowly as possible, according as the engine is working at full power or at the lowest number of revolutions.

Under present conditions the "aerobus" referred to above should be able to effect a landing at 50 m.p.h.; which means that it would require a clear 100 yards before coming to a dead stop. This distance, more than is necessary in the case of a head wind, may be reduced either by the use of brakes on the wheels of the undercarriage, or by the use of fixed or steerable tail skids fitted with springs, and biting the ground; another solution of this problem, which, owing to the fragility of the parts that have to absorb the recoil and to stand the shock of landing, has not yet been satisfactorily solved, may be found in the use of aeroplanes with a variable wing surface.

Now that the power of aeroplane motors has so greatly increased, while the weight per horse-power has diminished more than threefold, it will be possible to strengthen certain parts

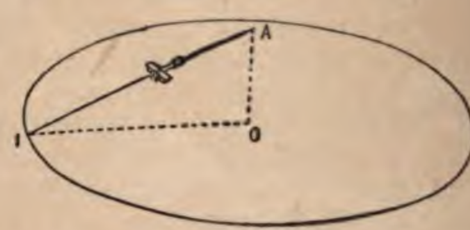
[1] See Appendix I.

without disadvantage and therefore to employ a safe and powerful system of brakes.

But it is essential to have sufficiently large landing places, free from all obstacles, to ensure alighting safely; and in order that the pilot may be certain of choosing such, if they exist, it is essential that he should retain as much freedom as possible in the control of his plane; but engine troubles will force him to descend in a volplane.

If an aeroplane "A" flying at a height of 7,000 ft. has a breakdown, it will be forced to glide down, that is to say that the planes will be inclined forwards and downwards. By changing the angle of inclination of the wings, the pilot can alight nearer or farther off, but the maximum distance "OI" which he cannot exceed is determined by an angle "IAO," which if it became greater would cause the machine to assume too upright a position to sustain it in the air, and would cause it to fall from lack of speed. A machine is said to have a gliding angle of 1/6 when OI = 6 + AO.

In the present case, A could alight within a




circle having a radius OI = 6 + 7,000 ft. = 7½ miles, equal to an area of forty-four square miles approximately. It follows that the higher a machine is flying, the greater is the area on which it is possible to land in case of a breakdown, and

For lack of room...

The only accidents to which properly designed and well built aeroplanes are liable, except those due to negligence, are those arising from forced leadings on unsuitable ground. This drawback would be non-existent if aircraft could ascend and descend vertically without having to run along the ground before taking off, or after alighting.

there is thus every advantage in flying high, especially over bad country for alighting.

The solution of the problem of safe flying is therefore the following. Since the only practical danger arises from a pilot being forced to descend owing to engine trouble, machines must be built with several independent engines, each one sufficiently powerful to keep the machine up in horizontal flight with a full load.

The requirements of such a machine, fitted with four 200 h.p. engines, would be as follows:

| | |
|---|---|
| Speed at 3,000 ft. . . | 100 m.p.h. |
| Alighting speed . . | 50 m.p.h. |
| Carrying capacity . . | $1\frac{3}{4}$ tons. |
| Time required to rise to 3,000 ft. . . . | 8 mins. |

As it is very improbable that two engines would break down simultaneously, the pilot would have ample time to seek a suitable landing place. Moreover an aeroplane in the course of flight progressively loses the weight of the fuel consumed; and even in the case of the complete breakdown of an engine which could not be repaired during flight, the machine would often have a sufficient reserve of power left to enable it to prolong its flight, even to complete its journey, under sufficiently safe conditions.

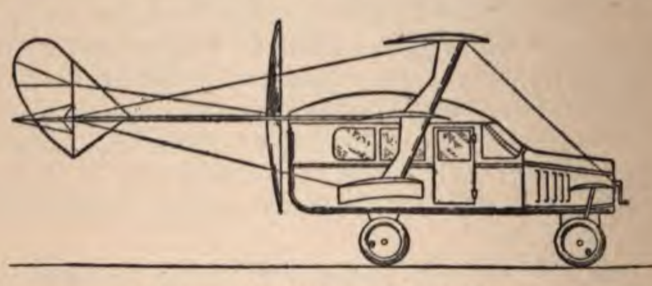
Thus there exist machines to-day capable of conveying goods and passengers as safely as automobiles or steamers.

FITTINGS.—Safety, the most essential condition, having been ensured, what are the other qualities required by an aeroplane engaged in regular transport work? In addition to speed, regularity, and carrying capacity, which will be dealt with in

detail in a later chapter, comfort is essential for a regular commercial service. And it is scarcely needful to add that the prices charged must not be prohibitive.

AMERICAN AUTOPLANE.

Just as the chassis of an automobile can be fitted with different types of body (*e.g.* torpedo, limousine, lorry, etc.) according to the purpose for which it is needed, it will be possible, in the



LONGITUDINAL SECTION OF THE ABOVE.

same way, to fit up the body of an aeroplane as suitably and comfortably as is required, provided that such fittings are not too heavy or too bulky.

So long ago as 1911, the Russian constructor Sikorsky had made successful trials with a

machine to carry fifteen passengers in a completely closed cabin, furnished with tables and chairs, and fitted with windows with mica panes.

In 1913 Blériot had built an aero-berline for the president of the French Automobile Club, as luxuriously fitted and upholstered as any automobile.

*Contreplaqué* wood or aluminium, which is both light and strong, can be used in the construction of aerial carriages just as practical in design as steamer cabins; and in order to offer as little atmospheric resistance as possible, cigar-shaped forms will be used like those already familiar to us in airship and submarine design.

To protect the passengers from cold (temperature falling roughly 5°5 C. per 3,000 ft.) the cabins will be heated either by special apparatus (*e.g.* petrol stoves, or electric radiators fed by a dynamo worked by the engine, or an auxiliary propeller), or by pipes heated by the exhaust gases or water from the radiator. Aeroplane bodies exist which are heated by the air used to cool the cylinders, and this system has been found to work satisfactorily.

Finally, all machines will be fitted with a wireless installation and will thus be in constant communication with land. This would be of the greatest benefit to business men and merchants.

Moreover as aircraft grow in size, their interiors will resemble those of steamers more and more; separate cabins fitted up with all the comfort necessary for a long journey; engine rooms enabling the machinery to be properly looked after and if necessary repaired in course of flight; proper accommodation for the pilot and his assistants, with the faculty of controlling the different parts of the machinery, such as variable wing

surfaces and day and night signals, at a distance. It may also be predicted that the speediest machines, and especially those called upon to fly at great heights, will have hermetically closed hulls, inside which a normal atmospheric pressure can be maintained.

PILOTS.—It has been suggested that it will be impossible after the war to provide properly trained and competent pilots in sufficient numbers to maintian regular services; but it is now scarcely possible to doubt that there will be no lack of them.

Whereas in France, owing to lack of funds, barely a hundred airmen were trained annually, the numerous flying schools since established, between which there is keenest competition to obtain licences, have turned out several thousands, and the number is on the increase.

And if new recruits are continually coming in, quantity has not affected quality, quite the reverse; it will be seen by casting a glance at the programmes of the successive tests for obtaining a pilot's licence, that the standard demanded is far higher than formerly.

In 1912 when the French military certificate was established, at the same time as that of the Aero Club, which was considered an easy test, the conditions required were three flights of thirty miles at 1,000 feet. In 1914 the conditions were changed to two straight flights of ninety miles without landing, or alternately one such flight and a triangular voyage of 125 miles, with two compulsory stops.

In 1915 a height test, absolutely essential for war conditions, was added; namely, an hour's flight at 7,000 ft. minimum altitude.

Lastly, extremely severe medical tests for eyesight, heart, and lungs have been added, which

Aircraft being reviewed.

enable a more and more exacting selection to be made.

Two French medical men, Drs. Broca and Neipper, have instituted a system of examination by means of specially designed instruments, by which they are able to ascertain and to record the psycho-motor reactions of candidates; and they have been able to eliminate many who, owing to the lack of the necessary coolness and mentality, would have risked almost certain death as fliers.

Moreover, while "stunt" flying was formerly strictly forbidden and military fliers were punished for attempting too steep volplane, or too sharp turns, owing to the numerous accidents which occurred due to faulty flying and badly built aeroplanes, the new training tests include "spinning dives" or "dead leaf" descents, giddy ascents, side slips, astonishing loopings—in fact every kind of stunt calculated to strain the structure, to make stays and struts vibrate, strain the fuselage, and give the coolest and boldest passenger a shiver! Our flying men experience a keen delight in manœuvring in every direction in space, in defiance of all laws of weight and stability! But aeroplanes capable of standing such exacting tests should fill future aerial travellers with perfect confidence.

Thus both the number and the skill of fliers are steadily increasing; and the same may be said as regards the specialised workmen engaged in construction and repair work, who have acquired unequalled skill and experience during the war. Aerial navigation companies will have no lack of material from which to recruit a thoroughly competent and trustworthy personnel.

We may thus hope to have at our disposal a

regular fleet of swift, safe, and comfortable aircraft, of reasonable carrying capacity, qualities which are certain to increase steadily, so that we may predict the existence in a comparatively near future of machines able to carry 10 tons at a regular speed of 125 m.p.h. And these hopes are by no means utopian.

Who could have foreseen when the Wrights made their first public flights, that in a few years' time regular squadrons of aeroplanes would be fighting pitched battles in the air, and that hundreds of miles would be flown without a stop, at speeds unattainable by any other form of locomotion?

With such a marvellous means of transport at its disposal, what advantages is humanity likely to derive from it?

# CHAPTER II

## AN AERIAL POSTAL SERVICE

THE first regular and permanent air service to be organised is undoubtedly a postal one. For the great speed of aeroplanes and their limited carrying capacity can be made use of to the greatest advantage in the conveyance of mails.

The first trials were made in France in October 1913, when Lieutenant Bouin carried S.A. mails from Villacoublay (near Versailles) to Pauillac (near Bordeaux) for the outward-bound s.s. *Perou*. The official inauguration of the first Franco-British aerial post took place on August 17, 1918, at Le Bourget, under the presidency of M. Clémentel, French Minister of Commerce. An example is enough to show the importance of this measure. Under war conditions, letters from Paris to London and *vice versa* take at least forty-eight hours (often longer) to reach their destination; under peace conditions, the quickest (by the night mail) were at least twelve hours on the way; if posted in the morning they might take twenty-four hours to arrive.

A letter sent by aerial post and delivered by special messenger should reach its destination within four hours, that is, as fast as a telegram, and the reply could be delivered the same day, whereas by ordinary post this would require at least three days. It is probable that parcels of

a certain weight and size will also be carried by air; and it is easy to see the commercial advantages of such a means of transport for the conveyance of such articles as business documents, articles *de luxe*, expensive perishable goods such as fruit and flowers, and many others.

### Regularity of a Permanent Air Post

One great objection to the working of such a service will at once be put forward: aeroplanes are only able to fly under favourable weather conditions, and it will therefore be impossible to maintain a regular service. But next to safety, regularity is essential to the successful working of such a postal service. Will not the uncertainty as to times of departure and arrival, as well as the possibility of the service being completely interrupted, be a fatal obstacle to the popularity and success of the service?

Let us therefore examine these objections more closely.

It is clear that, owing to occasional adverse meteorological conditions, a regular service could not be guaranteed *every day*. Heavy rains, high winds, thick fog, still constitute almost fatal obstacles to aerial navigation; and on an extended route there will often be "atmospheric barrages" which an aeroplane will sometimes find it difficult, if not impossible, to traverse. Having left Paris in fine weather, a machine may encounter heavy rain at Dijon, fog at Lyons, mistral in the Rhone Valley, and bright sunshine again at Nice. But although it will be impossible to guarantee daily journeys, and to predict with certainty what days will be "fliable" or not, it does not follow that we should on that

account completely forgo the advantages of an aerial postal service. Moreover, "non-fliable" days will tend to become continually fewer, on account of the constant progress in aircraft construction and the art of flying.

A necessary feature of the service will be the establishment of special signals at every flying station and at every post office dealing with aerial mail matter, indicating, a few hours before the scheduled time for the collection of air mails, whether these can be dispatched by air or not.

Nor should there be any difficulty in supplying this information. The termini and intermediate stations of all aerial lines will be connected by wireless or by telephone, if not by both, and the weather conditions will be known along the whole route. When these render flying out of the question, the public will be informed that the air mails will be forwarded by ordinary means, and will be distributed at the usual times.

The same result can be attained in the case of a breakdown occurring, and the postal aeroplane being unable to proceed. The intermediate air stations will be provided with fast motor-cars which will in such cases immediately proceed to the scene of the breakdown and convey the mails to the nearest air station, or if necessary to a railway station.

We can thus see that the hindrances to a *regular* air service are only analogous to those already existing in the case of telegrams, where the existence of offices closed at night and during holidays, and the effects of storms, often cause considerable delay in the delivery of messages. It must not be forgotten that aviation is still in its infancy; and the continual improvements already made, particularly in the domain of automatic stability,

may lead us to hope that in the near future flight will be practicable under all atmospheric conditions.

### Time-tables

The principle of a regular air service being established, we must determine what the conditions are under which it would work; in other words, a time-table must be drawn up.

If we assume that for the present, and until night flying becomes quite safe, voyages will only take place by day, the "commercial speed" of an aeroplane will depend on four main factors:

(*a*) The duration of daylight in the regions traversed.

(*b*) The strength and direction of the wind.

(*c*) The length of intermediate stops.

(*d*) The cruising speed of the machine at the mean altitude of its flight. Examining each in detail, we find:

That in preparing for long-distance journey, the unequal length of day and night at different seasons and in different latitudes must be taken into consideration.[1]

The following table shows the varying length of daylight at different latitudes at any given time of year.

| — | Summer Solstice. | | | | Winter Solstice. | | | |
|---|---|---|---|---|---|---|---|---|
| | N. Hemisphere. | | S. Hemisphere. | | N. Hemisphere. | | S. Hemisphere. | |
| | h. | m. | h. | m. | h. | m. | h. | m. |
| Equator | 12 | | 12 | | 12 | | 12 | |
| 20° | 13 | 12 | 10 | 48 | 10 | 48 | 13 | 12 |
| 30° | 13 | 56 | 10 | 4 | 10 | 4 | 13 | 56 |
| 40° | 14 | 52 | 9 | 8 | 9 | 8 | 14 | 52 |
| 50° | 16 | 18 | 7 | 42 | 7 | 42 | 16 | 18 |
| Arctic Circle | 24 | | — | | — | | 24 | |

[1] See Appendix III.

It is easy to grasp the importance of these facts when we note that in France, for example, the average length of the day at the solstices is about 16 hours in summer and 8 in winter; a difference of 8 hours, equivalent to 720 miles at 90 m.p.h.

When flying by night becomes as easy as by day (and the experience of war has shown that night trips were perfectly feasible, with thoroughly reliable engines, routes clearly marked by lights, and properly arranged landing places), this question will not be so important; but until then it must be taken into consideration in drawing up aerial time-tables, as well as another factor, namely the earth's rotation on its own axis, which results in difference of time between places not situated on the same longitude. When it is 12 p.m. at Paris, for instance, it is 12.40 at Rome, 16.42 at Bombay, 21.9 at Tokio, and only 6.55 at New York.

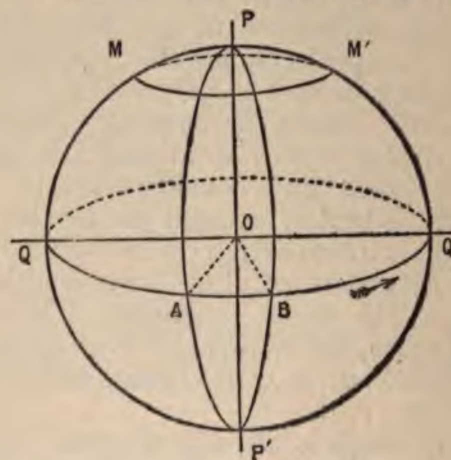
This fact, which is already of some importance to railway travellers (there is one hour's difference between French (Greenwich) time and Central European time), is considerably more so in the case of aircraft, that are so much faster and can therefore in the same day effect far greater differences of longitude.

For example, let O be the earth, rotating on its own axis PP′ in the direction of the arrow; QQ′ the diameter at the equator; MM′ a parallel; then, the circumference being divided into 360°, it follows that every point on the earth's surface turns $\frac{360}{24} = 15°$ in an hour, and that consequently four mins. of time $= 1°$.

As the length of the circumference is approxim-

ately 24,000 miles, the length of a degree at the equator is $\frac{24,000}{360} = 66$ miles.

If the angle AOB = 10°, the difference of time between the two points A and B will be forty minutes; it follows that an aeroplane proceeding




from B to A can start from B forty minutes earlier by daylight; whereas, flying from A towards B, it would run the risk of being overtaken by nightfall before arriving at its destination, if the journey is reckoned according to time of the place of departure.

For supposing that both places, A and B, have adopted the time of the meridian of A, an aeroplane starting from A at sunrise, *i.e.* at 6 a.m., will only have 11·20 mins. of daylight for its journey, since it is already in reality 6.40 at B when it leaves A. Conversely, on a flight from B to A, leaving B at sunrise it would have 12·40 for the journey, since it would have left B 40 minutes before the sun rose at A.

Therefore a plane flying round the equator at a speed of $\frac{24,000}{24} = 1,000$ m.p.h., and in the opposite direction to the earth's rotation, would have the sun always at the same height above the horizon.

As the degrees of longitude diminish in length as they near the poles, it follows that at a given latitude the speed of the earth is no greater than that of an aeroplane; the latter would therefore

The speed of a point situated on the earth's surface in lat. 85° N. is 90 m.p.h. An aeroplane flying in the opposite direction to the earth's motion at this speed, and following the 85th parallel, would keep pace with the sun; and at a higher speed would even overtake it, arriving at certain places the day before it had started!

be able at this latitude, except in the arctic circles, to fly always at the same time and in perpetual daylight.

For example, the length of a degree of longitude, in 85° N. or S. latitude, being six miles, the length of the circumference is only $6 + 360 = 2,160$ miles. Therefore an aeroplane with a speed of $\frac{2,160}{24} = 90$ m.p.h. would complete the circumference of the 85th parallel in twenty-four hours!

Travelling westwards at a higher speed, it would travel faster than the sun, and could arrive at certain places on the eve of its departure!

INFLUENCE OF ATMOSPHERIC CURRENTS.—The influence of various atmospheric currents on

aerial navigation cannot but be considerable, owing to the fact that an aeroplane is upheld by the air which surrounds it, and therefore participates in all its movements. An ordinary balloon is entirely at the mercy of the currents, but if it is fitted with propellers, like an airship, it then acquires a speed of its own, and can either make headway against an unfavourable wind, or add the speed of a favourable one to its own.

Thus the rate of speed of an aeroplane in relation to the ground depends upon the power and directions of the surrounding currents, and is governed by the mechanical law of opposing forces. If both aeroplane and wind are proceeding in the same direction their respective speeds are additional to one another; in the opposite case the resulting speed is equal to their difference.

For example:

Let $V$ = speed of aeroplane by itself.
$v$ = speed of wind.
$Vv$ = consequent speed of aeroplane over the ground.

Then, $Vv = V + v$ with a following wind.
$Vv = V + v$ with a head wind.

If the speed of the wind is equal to or greater than that of the machine, then $Vv = o$, or $Vv = v - V$: in the former case, the aeroplane remains stationary, in the latter it recedes.

Let A be an aeroplane with a speed of $V$; $v$ the speed of the wind; the resultant $Vv$ must be calculated according to the principle of the parallelogram of forces.

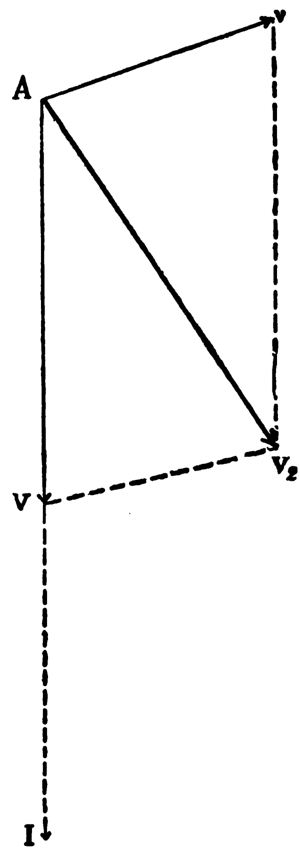
Supposing an aeroplane A is proceeding towards I at a speed of V.

Without wind it would proceed directly towards

I at a speed of V; but the effect of the wind causes:

(1) The machine to lose speed.

(2) To diverge from its straight line of route at




an angle $VAV_2$, which shows its *drift* from the line of route AI.[1]

It is true that it is now possible to foretell violent atmospheric disturbances a few hours in

[1] See Appendix IV.

advance, which is of great importance for long-distance flights; but for short flights in the temperate zones it must be admitted that we are more or less helpless in this matter, and we must recognise that it is extremely difficult to devise practical means of utilising atmospheric currents.

In the tropical regions there are, it is true, regular and powerful winds which blow almost continuously at certain seasons, but in the temperate regions the uncertainty of the winds is the rule. Experience has proved that certain "prevailing winds," which vary, however, at different seasons, exist in each region; but in the same day and in neighbouring regions unforeseen and sudden changes of temperature frequently occur, which are accurately recorded by delicate instruments, but are not as yet predicted by them with any certainty.

The scheme for crossing the Atlantic in a dirigible, which was drawn up in 1903 by Messrs. Elisée Réches, Berget, and Cappazza, was based on the force and direction of the trade winds. They estimated that starting from the Canaries during the first five months of the year and keeping at a certain altitude, it would be impossible to be driven elsewhere than on the coasts of South or Central America.

The average speed of the trade winds is about 33 m.p.h. at sea-level, probably only half again as fast at 1,500 feet; the extreme limits of the journey's duration could therefore be ascertained by:

(1) Dividing the longest distance by the slowest speed;

(2) The shortest distance by the highest speed.

(1) gives $\frac{5,000}{33}$ = 151 hours; Canaries to Yucatan.

(2) $\frac{2,600}{50}$ = 52 hours; Canaries to Para.

An aeroplane crossing the Atlantic under these conditions would effect a great economy of time and fuel, as the following table shows:

| Route. | Distance. | Average speed. | Time. | Proportion of fuel consumption between the average and the minimum times. |
|---|---|---|---|---|
| | | | hours. | |
| Canaries to Yucatan | 5,000 | 105 m., normal speed | 47 | |
| | | 135 m., with following 30-m. wind | 36 | |
| | | 155 m., with following 50-m. wind | 32 | Approximately 3:2 |
| Canaries to Para | 2,600 | 105 m., normal speed | 24 | |
| | | 135 m., with following 30-m. wind | 19 | |
| | | 155 m., with following 50-m. wind | 16 | |

In the early days of flying, winds and eddies were a great danger; slow-flying "tangent" machines struggled with difficulty against currents which would now be looked upon as relatively slight, and were greatly affected by every kind of atmospheric disturbance; during the warm hours of the day, flying over woods and valleys, a fertile cause of air pockets and eddies of all kinds, was an arduous and hazardous business for the unfortunate pilots, who, struggling desperately against the violent currents, could only maintain themselves by rapid and continual manipulation of the rudders. Many lonely struggles of this kind ended fatally owing to the weakness of the machine or the collapse of the pilot.

But with the increasing stability of machines,

due to greater weight and speed, they have become able to skim harmlessly over dangerous air pockets, the obstacle being successfully navigated with only a slight tremor or a scarcely perceptible shock to the machine.

But is this equivalent to saying that flight is possible in all weathers? Scarcely, since there is always an obstacle which no machine can overcome, namely when the speed of the wind exceeds the speed of the machine. In that case, to remain indoors is the wisest policy.

In order to ensure that aerial services shall run as regularly as possible, it is obviously of advantage to use machines able to fly successfully against most winds; and for this the probable speed and frequency of the winds likely to be

met with on any given route must be known as accurately as possible.

Meteorologists have made the following classification:

| | |
|---|---|
| Slight winds . . | 3–12 ft. per sec. |
| Moderate winds . | 12–25 ,, ,, ,, |
| Fairly strong winds . | 25–40 ,, ,, ,, |
| Strong winds . . | 40–50 ,, ,, ,, |
| Gales . . . . | 50–80 ,, ,, ,, |
| Hurricanes . . | over 80 ,, ,, ,, |

A speed of 135 feet per second is equal to 85 m.p.h., which is approximately the speed of the most violent hurricanes.

It is both useless and dangerous to expose a machine to violent gales. The experience gained during the last few years has shown that winds of 40 m.p.h. (60 ft. per sec.) are infrequent, and we are therefore justified in taking this figure as a maximum for a long-distance flight.

On this supposition, a postal aeroplane timed to fly from Paris to Bordeaux (320 miles) in eight hours (*i.e.* at 40 m.p.h.) will be capable of performing the trip in scheduled time in all weathers, if it has a speed of 40 + 40 = 80 m.p.h.

Stoppages.—But the speed mentioned above is that of a non-stop flight, and there are several reasons in favour of stopping *en route* at such towns as Tours or Angoulême, for example; important centres which there is every reason from a commercial point of view for calling at.

Moreover the amount of fuel needed for an eight hours' non-stop flight is considerable and leaves correspondingly less room for cargo, thus diminishing the profits.

A double-motor engine of 700 h.p. would consume, for instance, nearly 25 cwt. of oil and

petrol (in weight) in eight hours, and would therefore be able to carry eight passengers more if it replenished its reservoirs *en route*.

An aerial line should therefore be provided with several intermediate stations, the number of which would depend upon the loss of time involved in the number of stops and the respective length of each. Thirty or forty minutes should prove sufficient for refilling the tanks, for loading and unloading parcels and mail, and these figures may be taken as a provisional basis in drawing up a time-table; the former for express services, the latter for slower ones.

We are now in possession of all the factors for calculating the "commercial" speed of a machine working a permanent air service.

With four intermediate stations, for instance, between Paris and Bordeaux, the journey must be made in six hours instead of eight, and the average speed of the machine would then be 90 m.p.h. (52 + 38).

Should this speed be considered too high, on account of the consequent diminution of useful load, or for other reasons, the maximum speed of head winds to be allowed for may be reduced. In that case anemometric tables will show the probable corresponding reduction in the number of "fliable" days on the route under consideration.

Moreover, on a journey of this length, traversing regions with varying climates, and not always proceeding on the same course, the chance of meeting with continual head winds would be slight.

Experience alone, however, will furnish sufficiently accurate data for solving this problem. This is an additional reason for establishing permanent experimental aerial services, in order

to provide a solid basis of observations for ascertaining the real factors of their economic usefulness.

NORMAL SPEED AT AVERAGE FLYING ALTITUDE.—In building machines for carrying a given class of merchandise, one of the first questions to be settled is that of the most suitable speed. This is an apparently complex problem, since the factors to be considered in solving it are extremely various and sometimes contradictory; and in the course of this work we shall frequently have to refer to them.

For any given horse-power, the choice will lie between a comparatively slow machine with a large carrying capacity, and one of higher speed but unable to carry the same load. Some will prefer to be able to carry two tons, say, at 90 m.p.h., others a lesser load at a higher speed; and there is room for endless controversy in every case.

Take, for instance, a large machine of 700 h.p. able to lift 9 lb. per h.p. *i.e.* 6,300 lb., at a speed of 90 m.p.h. A small machine of 200 h.p., with a speed of 125 m.p.h. will only be able to carry $1\frac{2}{3}$ lb. per h.p., *i.e.* say 350 lb., at that speed. It would therefore require eighteen of these small machines, developing 3,400 h.p., to carry the same useful load.

In all kinds of locomotion, whether by ship, train, or motor, we find that speed is a terrible consumer of motive power.

We must therefore wait for the results of practical working to furnish us with the necessary data to work upon. But, in the meanwhile, we think that it is useful to prove that for any given line of air transport a minimum speed does exist, which it would be unwise in the present state of things to exceed. If this point of view is agreed upon, the problem will be considerably simplified.

Assuming the creation of a postal air service on a given route, we find that, as France is covered with a network of roads and railways, a postal aeroplane must have the advantage of speed over both trains and automobiles, since it has a smaller carrying capacity than either; while a trans-oceanic air service must employ planes capable of travelling faster than any vessel.

It may be noted in passing that the French railway system radiates from Paris, and that cross-country services connecting the eastern and western parts are even worse than in England. An air service between Valence and Angoulême, for instance, or along the Channel or Atlantic coast line, would effect a great saving of time for mails on these routes.

The average speed of a touring automobile is about 30 m.p.h., and that of a train 40. Let us therefore assume that we have an aeroplane at our disposal capable of 60 m.p.h. Under what conditions can it be employed?

In these latitudes (50°) the length of the day at the winter solstice is about eight hours; an aeroplane will therefore only be able to cover 480 miles in the day, while a train is travelling 960 miles in its day of twenty-four hours.

Moreover, the effect of winds must be taken into consideration. A following wind by increasing the speed will cause a gain of time which may be utilised either by starting later, by stopping longer *en route*, or by arriving sooner at the machine's destination. But in the time-tables only head winds which cause delay need be taken into account to allow for connections. Passengers will no doubt be glad to arrive ahead of time, but would never tolerate delays whose duration was always uncertain, and which might assume great

importance owing to enforced halts during the night. Supposing that a Paris-Bordeaux flying company, using a 90-mile machine, to have drawn up the following time-table:

| | Distance in miles. | Time taken. | Times: with 30-min. stops. |
|---|---|---|---|
| | | | h. m. |
| Paris . . . . | — | — | D. 15 32 |
| Tours . . . . | 140 | 1 hr. 30 mins. | A. 17 00 |
| Angoulême . . . | 120 | 1 „ 20 „ | D. 17 30 |
| Bordeaux . . . | 65 | 40 „ | A. 18 48 |
| | | | D. 19 18 |
| | | | A. 20 00 |

In the latitude of Bordeaux, daylight does not last later than 8.30 p.m. on the longest and clearest days. On the above timing, therefore, a machine which was delayed more than thirty minutes would fail to arrive at its destination the same day, and would be obliged to wait until the next day to resume its journey.

As the slightest head wind would be sufficient to cause such a delay (a head wind of 13 m.p.h. would delay a machine 30 mins. in 320 miles), it follows that the above time-table must be changed in order to ensure the arrival of the mails at Bordeaux before nightfall.

A certain maximum speed of wind must therefore be taken at which machines will not fly, or at any rate at which connections will not be guaranteed; and this speed must form the basis of calculation in establishing time-tables.[1]

Basing ourselves on the results of flights during the past few years, we fixed this speed at forty miles. But on this assumption, the aeroplane

[1] A table of average winds on a given route must not only indicate the *strength* of the atmospheric currents at different altitudes, but also their *direction*, in order to be able to determine their action upon the

in question progressing at only $64 - 40 = 24$ m.p.h. would barely cover 200 miles in a day's flight, which is equivalent to only 8 m.p.h. This without any allowance for stops *en route*. At such a speed it would take two days and a night to reach Marseilles from Paris (450 miles), which distance an express covers in less than a night.

flight of aircraft with any accuracy, for side winds naturally produce a different effect to those ahead or astern of a machine in flight.

Taking a course AB, an extract from the corresponding wind-gauge table shows:

| Normal wind speed, referred to the direction of flight. | Annual duration. | | |
|---|---|---|---|
| | On the ground. | At 500 m. (1,650 ft.) | Etc. |
| Storms, hurricanes, fog, etc. - - - | 21 days | | |
| Winds above 60 km. (37.5 m.) p.h. - | 30 " | | |
| Winds above 40 km. (25 m.) p.h. - | 95 " | | |
| Winds above 20 km. (12.5 m.) p.h. - | 200 " | | |
| Light breezes - - - - - | 19 " | | |
| Total - - - - - | 365 " | | |

Subtracting the twenty-one days of stormy or foggy weather, when all flying is impossible, there remain 344 "fliable" days per annum.

Assuming that over a given course the wind will blow in one direction or in the the other about the same number of days in the year, then the journey AB must be performed on 172 days against a head wind; and if it is to be flown within a given time (*e.g.* daylight), the machine used must be fast enough to counteract the action of the maximum head wind; in other words its cruising speed must be 60 km. faster than would have been sufficient for performing the journey in still weather. . . .

If, for example, it is desired to fly from Paris to Nice, via Marseilles, 875 km. (546 m.) in the course of a long summer's day (*i.e.* 16 hours), the machine must have a "true" minimum speed of $\frac{875}{16} = 54$ km.p.h. without wind, plus the speed of the maximum head wind to be dealt with, 60 km., *i.e.* an actual speed of 114 km. (71·5 m.) p.h. Any diminution of this figure would reduce the number of annual "fliable" days. And should a machine capable of 94 km. (59 m.) be the only one available, the trip would only be possible $344 - \frac{30 + 95}{2} = 282$ days annually, instead of 344, since the speed of the wind is greater than 40 km. during $\frac{30 + 95}{2}$ days per annum. But a speed of $94 - 40 = 54$ km.p.h. is insufficient to perform the journey in 16 hours.

This shows the importance of night flying, especially in countries where an air service is competing with railways. It will therefore be essential to employ a machine, at once faster than at first proposed and also able to fly at night. How is it to be chosen?

Let us take a concrete case and attempt to determine the speed of a machine to be used on mail service between Paris and Bordeaux.

For the reasons already mentioned, it is clear that the distance must be covered in one day, that is at a speed of $\frac{320}{8} = 40$ m.p.h., taking the length of the shortest day as a basis of reckoning. But in order to counteract the effect of a head wind of the same speed, the machine must possess a reserve of power and be able to fly at $40 + 40 = 80$ m.p.h. in a calm. This should be the minimum speed of a postal plane used as a mail carrier on the Paris-Bordeaux route, flying without a stop and under the least favourable conditions (*i.e.* shortest day and maximum head wind).

It must also be able to carry the weight of fuel necessary for an eight-hour non-stop flight.

But it has already been pointed out that such a load will correspondingly lessen its commercial carrying capacity, and consequently its freight-earning powers. Moreover, there are several important places on the line of route, which air carriers would make calls at with advantage; and it would therefore pay to establish replenishing stations at such places.

Allowing for three scheduled stops of 30 minutes each, the flying time of eight hours is lessened by 90 minutes; and the machine with only 6½ hours at its disposal for covering 320 miles must have an ordinary speed of 45 m.p.h. and

consequently one of 85, to deal successfully with a head wind of 40 m.p.h.

It may be urged, however, that if a different distance had been chosen, the necessary speed would be modified. This is quite true, and is due to the fact that amongst the various factors determining the selection of a machine, the length of the journey and the necessity for covering it in one day, had been taken as a basis of calculation.

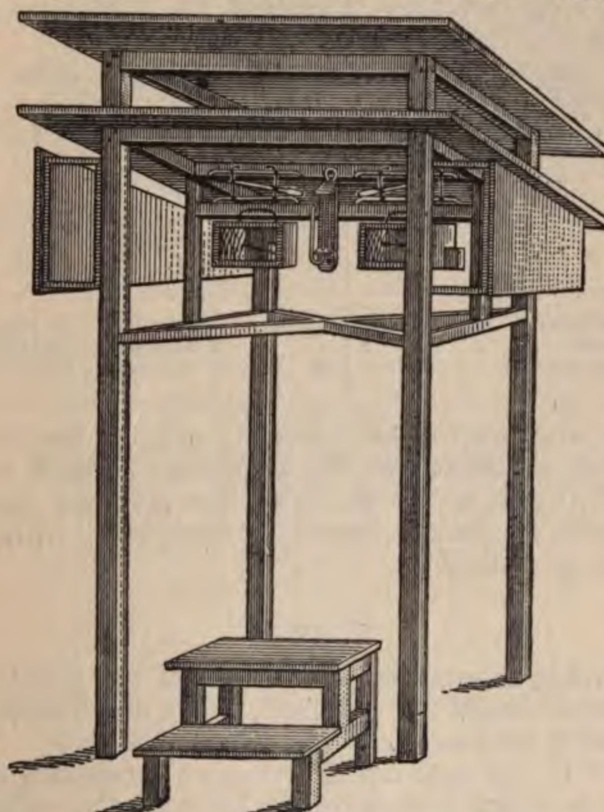
If any one factor of the problem (*e.g.* speed of wind, time of year, length of stops) is modified, the result will differ correspondingly.

Therefore to obtain a practical solution of the problem under consideration, the various factors must be classed according to their importance, and the solution must be in accordance with this classification as far as possible. To fulfil certain conditions will be a *sine qua non* of success, and these must therefore be dealt with first of all.

Resuming the study of the Paris-Bordeaux line, the first condition laid down was that the distance must be covered within the day; and it follows that the minimum speeds required are 75 m.p.h. for a non-stop flight, 85 for three halts. But a train travelling at 40 m.p.h. would also cover the distance in eight hours, and there would therefore be no advantage, as regards speed, in using an aeroplane for the carriage of mails; and this result would become even more marked over long distances where the train would continue travelling at night.

The aeroplane must consequently offer other advantages, such as lower rates, or the maintenance of a service by day in the absence of a day mail train; or, finally, it must be able to ensure a gain of time which the Post Office would look upon as appreciable; *e.g.* half a day in winter. In this

case, the aeroplane would have to cover the 320 miles in four hours, that is to be able to fly at 80 m.p.h. in calm weather and without stopping,



Meteorological instruments, such as thermometers, barometers, hygrometers, etc., should be placed in an open cage fitted with a double roof protecting them from the sun.

or at 165 m.p.h. with three halts of 30 minutes and against a head wind of 40 miles.

It thus appears that the speed required is growing dangerously in proportion to the carrying capacity, and that in civilised countries aircraft

will not easily succeed in competing with railways, especially on the main lines served by frequent expresses. In establishing international services over long distances, they will have to compete under the following conditions:

A train can cover $40 \times 24 = 960$ miles in twenty-four hours, which means a very high speed for an aeroplane, as shown by the following table:

| — | Length of day. | Speed without wind or stops. | Speed with a 40-m. head wind and four 30-min. stops (at 200 miles). |
|---|---|---|---|
| Winter Solstice . . . | 8 hours | 120 m.p.h. | 200 m.p.h |
| Equinoxes . . . . | 12 ,, | 80 m.p.h. | 136 m.p.h. |
| Summer Solstice . . . | 16 ,, | 60 m.p.h. | 106 m.p.h. |

As appears in the following graphs, however, aircraft would regain the advantage of their own speed if able to fly at night (*i.e.* average speed of train 40 miles; speed of aeroplane, without wind, 90 miles).

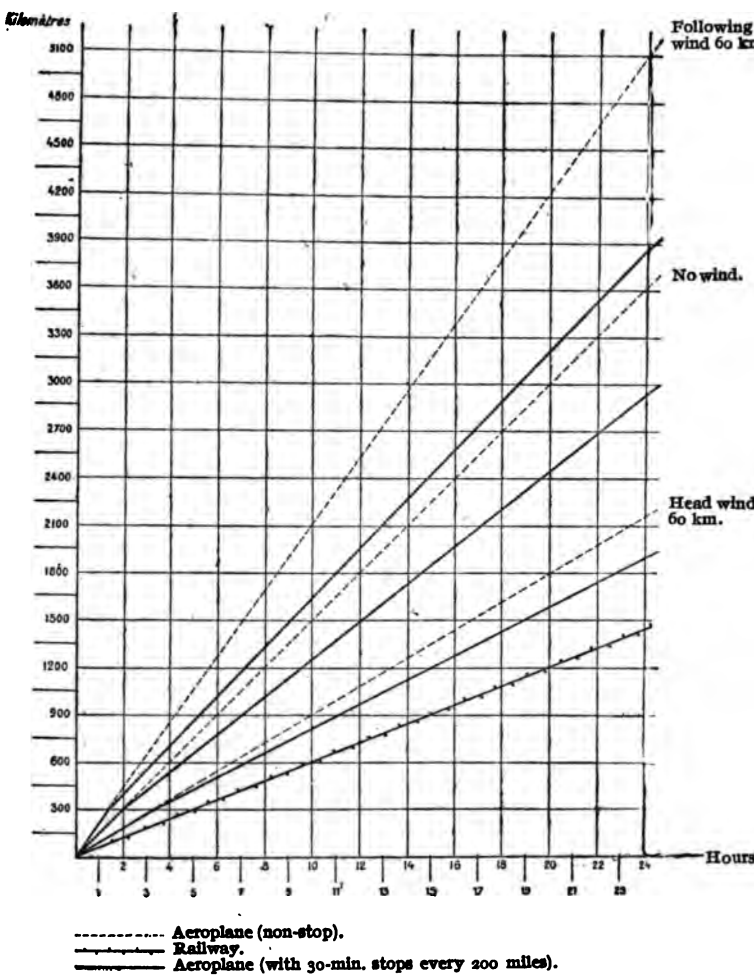
### Graphs

Having altered the conditions of the problem, different results are obtained, as we had foreseen; for each problem has its own solution.

But in any case aerial transport companies will have to effect a compromise between the various factors, that will contribute to determine the required type of machine, at any given period of aviation.

In carrying mails, passengers, or merchandise, they will always have to face the serious competition of the railways. It is probable that they will prove successful in the course of time; but, as we shall see later, it is in the colonies and for

trans-oceanic lines that they will obtain the best results at first.




On the strength of the preceding arguments the following formulæ relating to the commercial speed of aircraft may be established :

Let L = total distance of route.

V = normal speed of aeroplane assumed to be constant.

$Vm$ = average speed of aeroplane on a given course L.

$v$ = average speed of fastest head wind which the aeroplane can fly against.

$n$ = number of intermediate stops.

$r$ = average time of each stop.

The duration of a non-stop flight without wind, $= \frac{L}{V}$;

with following or head winds $= \frac{L}{(V \pm v)}$; with $n$ stops of a total length $t = \frac{L}{(V \pm v)} + nt$.

In the last case the average speed will therefore be:

$$Vm = \frac{L}{\frac{L}{(V \pm v)} + nt} \qquad (1)$$

This formula will be made use of in drawing up the daily time-tables for aerial lines.

If the journey lasts longer than one day, the length of time during which no (night) flying takes place will lessen the average speed of the aeroplane in proportion to its own length.

Let J = "flying time," *i.e.* during which flight is possible by daylight.

Then the average speed in twenty-four hours will $= Vm \frac{J}{24}$;

and finally the formula is:

$$\text{Speed for 24 hours} = \frac{L}{\frac{L}{(V \pm v)} + nt} \times \frac{J}{24} \qquad (2)$$

When regular night flights become possible, J = 24, and formulas (1) and (2) become identical.

Thus we find that for aircraft, as for all other vehicles, "the commercial speed over a given distance, being the average speed of the craft between the two extreme points," is found by dividing the total distance by the length of time taken to cover it.

What will be the speed of an aeroplane covering a certain distance in a given time T?

Without wind or stops, and in one day, it will be: $\frac{L}{T}$;

with stops: $\frac{L}{T - nt}$;

with stops and wind $v$:

$$V = \frac{L}{T - nt} \pm v. \qquad (3)$$

This will be the aeroplane's speed in the least favourable case.

If T is greater than the length of one day, then J, J′, J″, J‴ . . . etc., representing the succeeding and varying length of "flying time" per twenty-four hours, we have:

Speed without wind or stops:

$$\frac{L}{J + J' + J'' + \ldots};$$

with $n$ stops:

$$\frac{L}{J + J' + J'' + \ldots - nt};$$

with wind and stops:

$$\frac{L}{J + J' + J'' + \ldots nt} \pm v. \qquad (4)$$

From the preceding the following conclusions can be drawn.

Whereas the commercial speed of railway trains depends upon factors that are almost fixed, or at least subject to very slight uncertainty (*e.g.* speed of the train itself, known changes of speed at starting and stopping, length of intermediate halts): in flying, an extra and eminently changeable factor must be taken into consideration, namely, the strength of the wind. And in addition, as long as night flying is more difficult than flight by day, another factor liable to effect the duration of flights in greatly varying proportions, according to place and season, must also be allowed for: namely the inequality of the length of day and night.

### Cost of an Aerial Service

The establishment and the working of a postal air service will entail comparatively heavy outlay. How are these expenses to be met?

Just as railways or shipping companies undertake the transport of mails on behalf of the Post Office, it would appear that the latter will find it advantageous to enter into contracts of a like nature with the future aerial navigation companies, which will also carry passengers and goods, unless the State prefers to operate the aerial lines itself. Assuming the former arrangement, we can examine conjointly the working of both services, and can attempt to answer some of the questions that will at once be raised.

(1) What will be the initial cost, and the working expenses, of aerial transport lines?

(2) What requirements will they have to fulfil to repay such outlay and earn a profit?

(3) Will not the rates, equally for mails, passengers, and goods, prove prohibitive?

(4) What rates of postage will be fixed? Taking once more the concrete example of a line working from Paris to Bordeaux, let us examine its conditions of working.

On the assumption that a machine capable of flying 90 m.p.h. with fuel sufficient for a five hours' flight is at our disposal, a digression becomes necessary.

So far it has been argued that the qualities of a machine (*e.g.* speed, useful load, etc.) would depend on the use to which it was to be put. Let us change this reasoning in order to attack the problem from all sides and to facilitate the reader's task.

It is, moreover, quite clear that for reasons of economy the first machines employed for postal work will be those already built for war purposes. Millions having been spent in the construction of our military squadrons, it would be clearly impossible to leave all these machines (which rapidly become out of date) idle. Their employment on mail work would seem to be indicated, and it will therefore be necessary to take their characteristics into consideration in establishing a service.

The first question to be faced is the choice of route. This should be as direct as possible and above already existing lines of communication, such as roads or railways and connecting important centres, so that no time may be lost in needless deviation, and also that machines may be quickly succoured in case of breakdown. Further, as we have already seen, two other factors will determine the position of landing places: the commercial advantage in calling at important

economic centres, and the necessity for replenishing fuel *en route*.

The latter condition is to be understood as follows: machine flying for five hours at 90 m.p.h. would cover 450 miles in that time, without wind or stop. But this will not always be the case, and its speed over land will be diminished according to the strength of head winds.

With a head wind of 40 m.p.h., its speed will be reduced to 50 m.p.h., equivalent to only 250 miles in five hours' flying time.

This is therefore the greatest distance which should separate adjacent revictualling stations; and in practice and to guard against all incidents, it may be put at 275 miles.

On this basis, the time-table would be as follows:

| | Distances. | Duration of journey. | | | | | |
|---|---|---|---|---|---|---|---|
| | | Normal speed. | | With 40 m.p.h. wind. | | | |
| | | | | Following wind. | | Head wind. | |
| | | Non-stop. | With stops. | Non-stop. | With stops. | Non-stop. | With stops |
| | | hr. min. | hr. min. | hr. min. | hr. min. | hr. min. | hr. min. |
| Paris | — | — | — | — | — | — | — |
| Tours . . | 190 km. | 1 17 | 1 47 | 55 | 1 25 | 2 7 | 2 37 |
| Poitiers . . | 98 km. | 39 | 2 56 | 28 | 2 23 | 1 5 | 4 12 |
| Angoulême . | 102 km. | 40 | 4 6 | 29 | 3 22 | 1 8 | 5 50 |
| Bordeaux . | 110 km. | 44 | 4 50 | 31 | 3 53 | 1 13 | 7 3 |
| | 500 km. | 3 20 | — | 2 23 | — | 5 33 | — |

From the above it appears that it is possible to accomplish the journey, under any conditions, in five hours non-stop, except against a continual head wind of 40 m.p.h., which should prove rare over such a long distance; in case of delay, there-

fore, a machine will be able to arrive up to time by omitting the intermediate stops.

WORKING OF LINE.—The daily carriage of mails, as well as that of passengers and goods, would be ensured by two "teams" of three machines at least, with the necessary personnel and equipment, and having their respective bases at the terminal stations.

Half as many planes and engines as were in regular use would constitute a reserve, with pilots for half the reserve machines. Every machine would also have a certain number of mechanics assigned to it, in accordance with its size, engine power, etc.

The "flying stock" would thus consist of three active machines at Paris and Bordeaux, and one reserve machine and engine at each station (*i.e.* three in all at Paris, Poitiers, Bordeaux). The personnel would comprise three pilots on duty at Paris and Bordeaux, with one in reserve at Poitiers and the latter place; while three mechanics would always be on duty at the terminals, with one in reserve at each of the three stations.

Thus, each machine or group of machines would have about forty hours' rest every two days, which should be sufficient for current overhauling and for resting the pilots.

The (stationary) personnel would consist of a general manager with technical and commercial assistants; of a certain number of inspectors and surveyors according to the needs of the traffic.

Each station would have its station-master and assistants; and in addition would be provided with mechanics, carpenters, and sail-makers for the upkeep of the stock; also porters, storekeepers, motor-drivers, etc.

As to buildings, each air station would com-

prise a suitable landing place, dwellings for the personnel and aeroplane sheds, a repair shop, a stock of accessories and spare parts, and a depot of fuel and lubricants. Finally each station would be in telephonic communication with all others and would have a certain number of motor vehicles at its disposal.

To ascertain the cost per mile or per trip of such an undertaking during a given time, an estimate of the cost of buying and keeping up the "flying stock" and of the salaries of the personnel must be drawn up. This having been obtained, this figure must be divided by the total number of miles flown, or by the number of journeys made within a given period of time.

The data thus obtained will obviously be merely approximate, but will at the same time show that such a problem is not insoluble. The experience gained during the last ten years provides us with sufficient data to prove that the cost of the journey from Paris to Bordeaux, with the organisation sketched out above, should not exceed 2,000 frs. (£80). (See note at conclusion of chapter.)

To recoup its expenses a company carrying only mails must therefore be in a position to carry a number of letters and parcels on each machine representing an equivalent value.

In these circumstances, what rates could be charged?

Since a letter would reach its destination by air post as quickly as a telegram (over short distances), it would appear that the same rates might be charged. But it would be most unwise to charge a rate *per word*, since this would do away with all the advantages of privacy of correspondence ensured by a sealed letter; nor would the Post Office derive any profit, since it is clear that,

within certain limits, the real value of consignments by aeroplane are to be measured *by weight*. On the other hand, it must not be forgotten that flying will not be possible every day of the year, which means uncertainty for the sender, and must necessarily prove a hindrance to the success of the undertaking.

The public must therefore look upon the extra postage charged for aerial mails in the light of a premium payable for the advantage of sending mails more quickly by air than by any other means; and the rate charged must be smaller in proportion as that possibility diminishes.

If machines can only fly from Paris to London, for instance, during 200 days in the year, it will be impossible to charge as high a rate as if flying takes place regularly every day. The rates must therefore be lowered in consequence, this being in the nature of a "reduction for uncertain working." There is moreover little danger that the postal authorities would find the rate too low, as in that case they would be injuring themselves by causing a diminution in the daily number of telegrams dispatched.

A fresh element of uncertainty now arises. The means of transport have been provided, but will there be goods to carry? What quantities of mails will be dispatched? And will the aircraft not run the risk of starting empty, or at least with a freight insufficient to cover working expenses?

Experience alone can afford a conclusive answer.

An interdepartmental commission for civil aviation was established in France by the decrees of June 15 and 23, 1917, for the study of all questions relative to the utilisation of flying; and this commission has recently undertaken a series

of trials over a given distance. When the results of these trials have been properly worked out, the Post Office authorities will have the necessary data available for making contracts with companies granted concessions for the aerial carriage of mails, in the same manner as with shipping companies.

It is also possible that the Post Office may decide to work lines itself, and several such lines have already been started in the French Colonies, at the instigation of M. Clémentel, French Minister of Commerce, and are said to be working successfully.

Allowing for the number and cost of telegrams dispatched daily, and for other kinds of rapid communication in use (*e.g.* telephone, express messages, pneumatic cards) a rate of 2 frs. per air letter not exceeding 10 grammes (*i.e.* roughly 1*s.* 9*d.* for ⅓ oz.) would seem fairly reasonable; it will always be preferable to give the public the satisfaction of a subsequent reduction than cause painful surprise by an increase.

At this rate, it would therefore require at least 975 letters, or parcels of an equivalent weight, to pay the expenses of a 320-mile voyage.

But at this rate, a passenger weighing 12 st. 8 lb., or equal to 8,000 letters, would have to pay 16,000 frs. (£640) for a trip from Paris to London.

But if the price per person is fixed at 300 frs. (£12), it will only require ten passengers to cover the cost, or even five passengers and 750 letters, which does not at first sight appear excessive.

Moreover, let it be noted, these rates are calculated for a machine doing 105 m.p.h. If this speed be reduced by only 15 miles, the machine will then easily be able to carry thirty passengers, which would diminish the cost of the Paris-

London trip (200 miles in $2\frac{1}{4}$ hours) to $\frac{2,900}{30}$ frs. per person, or less than £4, for 300 flying days per annum with a full load.[1]

This figure could be reduced considerably if the company carried mails as well as passengers. For with a two-engine 300-h.p. machine carrying 400 kilos (880 lb.) of letters, worth 80,000 frs. (£3,200), the gain per trip realised would be $80,000 - 1,950 = 78,050$ frs. (£3,120), nearly 4,000 per cent.!

We may therefore hope that aerial transport companies will be able to make big profits; and we may presume that in the near future France will be covered with a network of aerial lines which will ensure much greater rapidity of intercourse, both within the country itself and also with her colonies.

### First Cost and Working Expenses of a Permanent Aerial Line of 500 km. (320 miles)

Under French climatic conditions it is assumed that flying will be possible 300 days per annum. The line will consist of two principal (terminal) stations and one intermediate station.

The regular daily service, one voyage in each direction, will be maintained by two groups of three machines, based respectively on the two termini.

The prices are based on post-war rates calculated from the data furnished by the experiences of the last ten years. It is estimated that the capital is to be redeemed within ten years.

#### *I. Postal Aviation*

The type of machine to be used is as follows:

Two engines developing 150 h.p. Speed, 150 km. (90 m.p.h.). Useful load, 400 kilos (880 lb.).

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[1] The cost of a Paris-London journey would be less than that of the Paris-Bordeaux service above mentioned, since it is 170 km. shorter. The conclusions arrived at put the aerial kilometric ton at 4 frs., which is certainly very high; but it should be possible to reduce this figure by half with slower aeroplanes of greater carrying capacity. This reduction would be even more marked in the case of Colonial services, and the continual improvements in aviation will have the same result

Our conclusions will then be based on the following figures:
Number of 500-km. trips per annum, 1,600.
Average length of each trip, 3 hrs. 20 mins., *i.e.* 2,000 hours per annum.
Distance covered per annum, 300,000 km. (187,500 miles).
(1) *Fuel consumption.*

| | |
|---|---|
| Petrol . . . . . . . . | 35 kilos per hour |
| Oil . . . . . . . . | 1·4 ,, ,, ,, |

*I.e.* in ten years: Petrol, $2,000 \times 35 \times 10 \times 2 = 1·400,000$ ks.
Oil, $2,000 \times 1·4 \times 10 \times 2 = 56,000$ ks.

Reckoning petrol at 55 cts. per kilo and oil at 1 fr. 50 cts. per kilo we obtain a consumption of 770,000 frs. (£30,800) of petrol, and 84,000 frs. (£3,375) of oil.
Or a fuel consumption of:

$$\frac{770,000 + 84,000}{6,000} = 142 \text{ frs. per trip.}$$

(2) *Engines.*
Price of engine, 15,000 frs. (£600).
Average length of working without an overhaul, 500 hours.
Average price for overhaul, 3,000 frs. (£120).
The initial engine establishment would consist of:

12 engines for 6 machines in use
4 ,, ,, 2 ,, ,, reserve
2 ,, in reserve.
Total, 18 engines.

Equivalent to a capital outlay of $18 \times 15,000 = 270,000$ frs. (£10,800). Assuming that one group of two engines is sufficient for working every trip, it would undergo thirty-nine overhauls in ten years (but as a matter of fact engines under repair would usually be replaced by reserve engines). This is equal to a sum of $3,000 \times 39 \times 2 = 234,000$ frs. (£9,375); giving an engine cost per voyage of:

$$\frac{270,000 + 234,000}{6,000} = 84 \text{ frs. } (£3\ 7s.).$$

(3) *Bodies.*
Price per body, 40,000 frs. (£1,600). Length of service without overhaul, 300 hours flying time (including allowance for probable accidents). Price per overhaul, 15,000 frs. (£600). Number of bodies, 8.
An entirely new body will be needed after 800 hours of flying.
Eight original bodies represent an outlay of $8 \times 40,000 = 320,000$ frs. (£12,800).
There will be 6·6 overhauls per annum of 2,000 hours flying time; *i.e.* 66 overhauls in 10 years, equal to 990,000 frs. (£39,600).
The cost per trip will therefore be:

$$\frac{320,000 + 990,000}{6,000} = 215 \text{ frs. } (£8\ 12s.)$$

(4) *Landing places.*
Two grounds of 100,000 sq. metres for each terminal station; one ground of 80,000 sq. m. for the intermediate station: total 180,000 sq. m.; which at 4 frs. per sq. m. near towns will come to 720,000 frs. (£28,800); *i.e.* 120 frs. (£4 16*s.*) per trip.

(5) *Buildings.*

| | Frs. | |
|---|---|---|
| At each terminus : | | |
| 1 shed for four machines and a motor garage . | 180,000 | (£7,200) |
| 1 office building . . . . . . . | 80,000 | (£3,200) |
| 1 repair shop and storehouse . . . . | 70,000 | (£2,800) |
| 1 dwelling house for staff . . . . . | 25,000 | (£1,000) |
| 1 fuel reservoir . . . . . . . . | 4,000 | (£160) |
| At the intermediate station: | | |
| 1 station building . . . . . . . | 15,000 | (£600) |
| 1 shed for three machines and one motor garage . | 60,000 | (£2,400) |
| 1 fuel reservoir . . . . . . . . | 2,000 | (£80 ) |
| Total . . . . . | 436,000 | (£17,440) |

Or, in ten years, about 56 frs. per journey.

(6) *Personnel.*

On a basis of the present rate of pay for airmen and mechanics, the cost under this head should not exceed 300,000 frs. (£12,000); *i.e.* 500 frs. (£20) per trip.

(7) *Miscellaneous.*

Included under this head are three automobiles at 16,000 frs. each = 48,000 frs. (£1,920)—and their upkeep; repairs and travelling expenses, cost of office fittings and furniture, instruments, lighting and heating, insurance, interest on capital, and unforeseen sundries. These expenses should not exceed 500,000 frs. (£20,000) per annum, *i.e.* 5 million francs (£200,000) in ten years, which means an average of 833 frs. (£33) per trip.

This would bring the total cost of each aerial journey of 500 km. (320 miles) to about 1,980 francs (nearly £80).

### *II. General Goods Carriage by Air*

To ascertain the cost per voyage for a regular " aerial bus " service, on the same system as before, our calculation will be based on the following type of machine:

Engines, four motors of 200 h.p. each.
Speed, 170 km. (106 m.p.h.).
Fuel for four hours' flight.
Useful load (exclusive of fuel), 1,400 kilos (3,080 lb.) = 17 passengers.
Average length of journey (500 km. at 170 km.p.h.), 2 hrs. 56 mins.
That is 1,760 hours flying time per annum.

(1) *Fuel consumption.*

| | |
|---|---|
| Petrol . . . . . . | 50 kilos per hour per engine |
| Oil . . . . . . | 6 ,, ,, ,, ,, ,, |

That is for four engines during ten years:

Petrol, $1{,}760 \times 50 \times 10 \times 4 = 3{,}520{,}000$ ks.
Oil, $1{,}760 \times 6 \times 10 \times 4 = 422{,}000$ ks.

Which represents a value of:

1,936,000 frs. (£78,000) of petrol.
633,000 frs. (£26,350) of oil.

Or 428 frs. (£17) per trip.

This is a maximum figure, since the amount of fuel to be carried diminishes with the distance covered, and the engine is working at a slower speed; therefore, in many cases flight will be possible with three, or even only two, engines running.

(2) *Engines.*

Price of engine, 20,000 frs. (£800).
Average length of working without overhaul, 500 hours.
Price per overhaul, 4,000 frs. (£160).
The initial number of engines required will be:

24 engines for 6 machines in use
8 ,, ,, 2 reserve machines
4 reserve engines

—

36 engines, representing a capital outlay of 720,000 frs. (£28,800).

As in former cases, the cost of overhauls during ten years will be:

$$4{,}000 \times 39 \times 4 = 624{,}000 \text{ frs. } (£26{,}000).$$

And therefore the cost per journey of the engines will be:

$$\frac{740{,}000 + 624{,}000}{6{,}000} = 224 \text{ frs. } (£9).$$

(3) *Bodies.*

Price of body, 60,000 frs. (£2,400).
Length of time without overhaul, 300 hours flying time (allowing for accidents).
Price per overhaul, 25,000 frs. (£1,000).
Number of bodies, 8.
These eight initial bodies represent an outlay of 480,000 frs. (£19,200).
For 1,760 hours flight per annum, 5·8 overhauls are reckoned, *i.e.* fifty-eight in ten years, equal to 58 × 25,000 = 1,450,000 frs. (£58,000).
The cost per trip is therefore:

$$\frac{480{,}000 + 1{,}450{,}000}{6{,}000} = 321 \text{ frs. } (£13).$$

(4) *Personnel.*

The increased staff of mechanics, carpenters, etc., required may be estimated as costing 100,000 frs. extra annually; or 166 frs. (£6 12*s.* 6*d.*) per trip.

(5) Finally, the item "buildings," which must be correspondingly larger, and "miscellaneous" will be increased by £2 and £8 respectively per trip.

Thus the cost per journey of 500 ks. (320 miles) for a permanent general carrier service under the above conditions will be about 2,900 frs. (£116).

# CHAPTER III

## AERIAL TOURISM

As already suggested, one result of the war will certainly be to popularise aviation, and with the return of peace numerous flying men will continue to feel the "call of the air," and many who have never flown will certainly be anxious to experience the new sensation, if only as passengers.

As in the beginnings of automobilism and motor boating, crack fliers will take part in competitions, and the young "aces" who have made a reputation at the front will succeed the old pre-war stars. It is fairly certain that aerial passengers will soon form a large class, which will be recruited in the first place among keen sportsmen seeking new experiences, women anxious for fresh sensations, all those afflicted with the speed mania, photographers and travellers. All these different types, some wealthy, some in a hurry, some from pure snobbishness, should all prove ready to pay generously for the opportunity of flying.

In those parts of the country most favourable to aerial navigation, from the nature of the soil, or on account of their wealth and dense population, companies will quickly be formed to provide facilities for aerial travel. Aerodromes will be laid out for the accommodation of private machines in specially built sheds, while hotels will be erected in the neighbourhood to accommodate their

owners in comfort. During the seasons most suitable for flying, it should not be long before facilities exist for hiring aeroplanes in the same way as cars may now be hired, or for making short excursions by air in regular touring machines, accommodating a number of passengers.

What a boon it will be for Parisians and Londoners to be able during the hot months to reach their favourite watering-places in an hour or less, and to receive their mail there quicker than a wire can now reach them.

It is a sign of the times that aeroplane designers are already contemplating, in addition to large and comfortable touring machines and huge "aerobuses," the construction of small, light one-seaters, regular aerial "motor bikes," whose price will not exceed £150.

It is scarcely necessary to mention the scheme for crossing the Atlantic and the Sahara by aeroplane, or reaching the Poles by the same means.

With the development of aviation distances will be enormously decreased, communication will become far easier and more frequent between all parts of the globe, activity of all kinds will be intensified, and civilisation will penetrate more speedily and thoroughly to the remotest corners of the earth.

### Cost of a Touring Machine

Touring machines will be built so as to afford their passengers complete shelter from wind, rain, and cold. Since travellers by aeroplane will effect notable economies in time, and will also avoid many expenses incidental to ordinary travel (*e.g.* cab fares, porters, hotels, meals *en route*, etc.), air

companies will be able to charge sufficiently high rates to make the business remunerative.

It has often been maintained that such a method of locomotion would be prohibitive in price; but exactly the same arguments were used in the infancy of railway travel, and later in the case of automobiles; and experience has shown conclusively that these objections were unfounded.

In our examination of the possibilities of an aerial mail service, we have already shown that the companies should be able to make handsome profits. The same will hold good in the case of companies formed for the purpose of providing touring facilities and employing skilled pilots and suitable machines of different types, in fact, with the necessary staff and flying stock suitable for such an undertaking.

It is common knowledge that aeroplane constructors have so far kept up the prices at a very high level, but it is almost certain that these prices will be considerably reduced in the near future.

Moreover, in pre-war days, such prices were justified by the great uncertainty of success in an entirely new enterprise, and the obligation to spend considerable sums in long, costly, and difficult experiments, which in many cases swallowed up the entire capital of the inventors.

Moreover, except for the strictly limited demands for military machines, the market for aeroplanes was exceedingly restricted; and as, from a business point of view, production on a small scale offers little attraction to capital, the profits to be derived from such a restricted output necessarily kept prices high, and in 1914 aeroplanes were exceedingly expensive.

Then came the war, and it became necessary to induce reluctant capital to come forward, to

erect complete factories, to buy machines, to organise regular armies of technical experts and skilled workmen and mechanics, to pay for higher freights and costlier raw material, and to cope with transport problems. Owing to the urgent need of getting orders executed at all costs, State control proved very easy-going, and prices remained "excessive."

But America came in and began to manufacture on a large scale; and this will be one of the reasons for predicting a speedy and inevitable fall in prices, similar to those which have already taken place in the motor-car industry. And it may be predicted that a machine for which the State was ready to pay £2,400 will not cost more than half this price when the military requirements are no longer greater than aircraft factories can supply.

When this is the case, the cost of aerial touring will no longer be prohibitive, for the following reasons.

For example, let us compare the cost of buying and running an aeroplane and a motor car which complete the same mileage.

The aeroplane taken is a four-seater with a 150 h.p. engine of the same kind as suggested for postal machines.

It is estimated that the life of the body would be three years (*i.e.* 900 hours flying time), but this figure is of course subject to great alterations according to circumstances, and during this period one overhaul annually will be needed.

These would cost in all about half the purchase price.

Therefore a 30,000 frs. (£1,200) machine (which is much less than many motors cost) able to fly 285 hours per annum at 140 km. (88 m.p.h.), which

means a total mileage of 25,000, would cost its owner as follows:

| | frs. | |
|---|---|---|
| Purchase price (complete with accessories) | 30,000 | (£1,200) |
| One overhaul of engines | 3,000 | (£120) |
| Two overhauls of body at 7,000 frs. | 14,000 | (£560) |
| Petrol consumption for 855 hours (55 cts. per kl.) | 16,458 | (£660) |
| Oil consumption for 855 hours (1 fr. 50 cts. per kl.) | 1,795 | (£72) |
| Total | 65,253 | (£2,612) |

To this must be added garage expenses, mechanics' wages, insurance, and sundries, which should not exceed £400 per annum. The total cost would thus be about 30,000 frs. (£1,200) per annum, which is not exorbitant compared to the cost of keeping a car.

For instance, a good, sound touring car, with steel-studded 80 × 120 mm. tyres, good for 3,000 or 4,000 miles without a puncture, will consume easily 0·11 gallon of petrol per mile (30 litres per 100 km.), (sixteen miles per gallon), and will be able to do 55 m.p.h. maximum and 35 m. on an average. Allowing for one thorough overhaul for 20,000 miles we get:

| | frs. | |
|---|---|---|
| Purchase price | 35,000 | (£1,400) |
| Petrol consumption | 14,250 | (£570) |
| Oil consumption | 825 | (£33) |
| Wear and tear of tyres | 17,850 | (£714) |
| Three overhauls at 5,000 | 15,000 | (£600) |
| Miscellaneous | 30,000 | (£1,200) |
| Total | 112,925 | (£4,517) |

Thus the cost of buying and running a car and a plane over a like distance of 120,000 km. (75,000 miles) will be about 18,000 frs. (£720) less for the latter; and there is therefore a good prospect that aircraft will be able to compete successfully.[1]

STEERING IN THE AIR.—To keep a proper course while flying, pilots steer by compass and map, and by the sun when it is visible; and also take their bearings from conspicuous objects on the line of route, such as towns, woods, rivers, or mountains. But when their machine drifts under the influence of the wind, it is difficult in the extreme to estimate the amount of such drift correctly; and when, flying in misty weather or above the clouds, they are unable to see the earth, it is often extremely difficult to get their right bearings and find their way.

Motorists travelling by road can find their way by signposts and mileposts; sailors at sea can take an observation, or if that is impossible work out their position by dead reckoning; but in the air, an aviator who has lost his way has no satisfactory guides. It has therefore been proposed to set up permanent guide marks on *land* to serve as sign-posts for flyers.

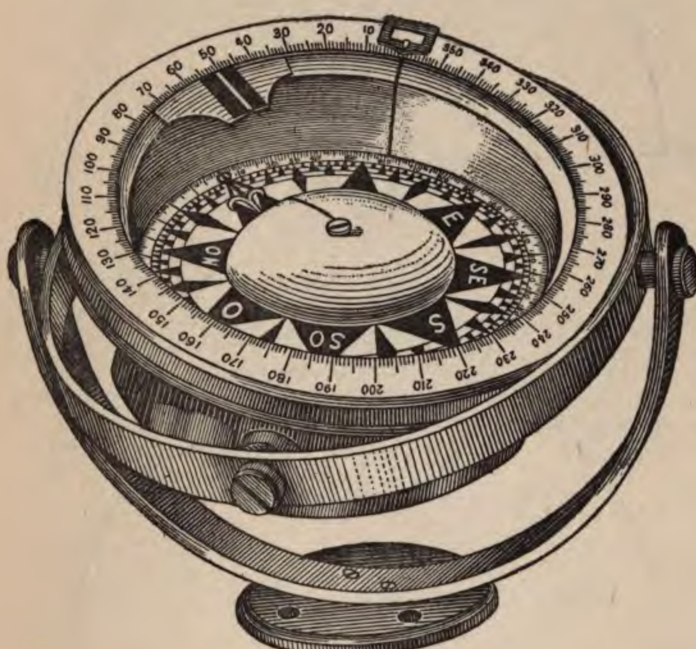
The simplest device is that of a large horizontal signboard, bearing the name of the town or district;

[1] The above figures do not, of course, imply that the two vehicles can carry an equivalent load. But if the one is a better weight-carrier, its rival is much faster, and we may therefore assume that these qualities balance one another, especially in the case of touring where speed, comfort, and the attraction itself of flying will be taken into consideration rather than actual commercial utility.

In any case, with the same h.p. (150) it would be possible to build an automobile as fast as our aeroplane, and with much the same carrying capacity (racing body); but not only would it be impossible to maintain such a speed (90 m.p.h.) on most roads, but wear and tear of tyres would immediately assume alarming proportions.

letters of three feet high, black on a white ground, can be read one kilometre (1,190 yards) away.

There would also be a second signboard, in the form of an arrow, bearing the name and distance



AEROPLANE COMPASS.

The magnetic disc floats in an unfreezable liquid which lessens the effect of jolting and vibration.

of the next important town, and pointing in the right direction.

The disadvantage of this method is that it would entail signboards of unwieldy size in the case of long names, and another method has been suggested. In this a special map is used and the signs are written in a conventional language of

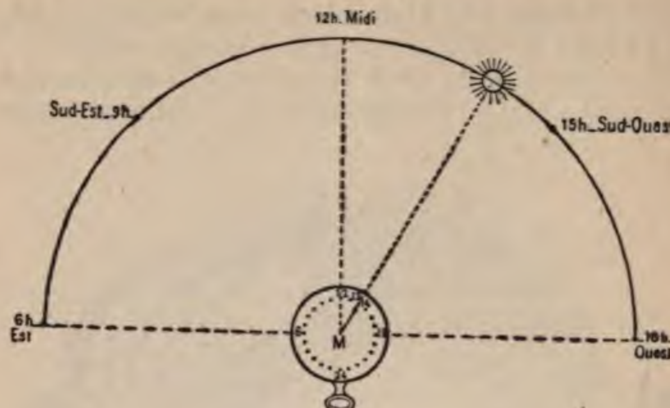



FIG. 1.

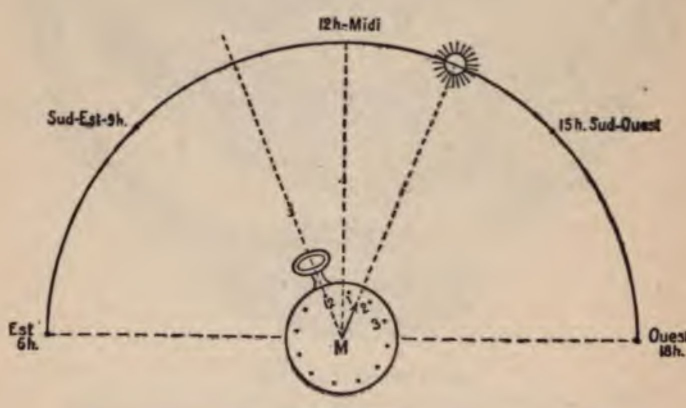



FIG. 2.

STEERING BY THE SUN.—Let Fig. 1 represent the apparent arc of the sun's daily motion round a given point M. At the equinoxes it rises in the east at 6 a.m., passes southward, attaining the highest point of its course at noon, and sets in the west at 6 p.m.

Let an observer situated at M turn the hour hand of a watch held horizontally, whose face marks twenty-four hours, in accordance with the sun's motion; then as the sun describes a semicircle of 180° (*i.e.* 15° an hour) round M, the hour-hand traversing an equal number of degrees in the same time will follow the sun's course exactly.

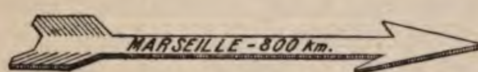
If, therefore, the hour-hand of the watch in question be pointed towards the sun at any time of the day, a line passing through its axis and the figure 12 will point due south.

If the watch only marks twelve hours, as is generally the case, the hour-hand, which makes a complete revolution in twelve hours instead of twenty-four, will be turning twice as fast as the sun; in this case a line bisecting the angle formed by the hour-hand and the straight line M—12 o'clock (Fig. 2) will point south.

signs and figures, which can be understood by reference to the map.[1]

In any case, for night flying, all the indicating


boards would have to be lighted by fixed or revolving lights, probably of different colours, to render them easily recognisable. But there can also be little doubt that wireless telegraphy will




prove of great assistance in this connection, and that all machines will sooner or later be fitted with a wireless apparatus.

### Aeronautical Maps

Special maps will be used for aviation, just as there are special charts for navigation at sea. These will omit all details useless to flyers, but will show, clearly marked, all the information which can assist aerial navigation; *i.e.* regular air currents; inequalities of ground; all ground dangerous or unsuitable for landing; aerodromes

[1] See Appendix V.

and other regular landing grounds; garage sheds; aero-stations; lighthouses and signals of all kinds; and silhouettes of certain striking objects (*e.g.* the Eiffel Tower, certain cathedrals and other monuments of great height, etc.) clearly visible at a certain height.

To arrest the pilot's attention more readily certain features of the landscape should be shown in suitable colours, *i.e.* rivers in blue, ploughed fields in brown or ochre, woods in green, etc.; and as much information shown on some maps and of great use to foot-passengers and motorists, would be of no value to aviators, the French staff-maps of 1 : 80,000 would be unsuitable. The Aero Club of France has adopted a type of 1 : 200,000 in colours which resembles that used by the Ministry of the Interior and is suited to the aviator's requirements. The growing length of aerial journeys will create a demand for international maps drawn up on a uniform plan and easily readable for travellers of various nationalities. This scheme is already being studied in England and in Italy, and M. Lallemand, Director of the French Ordnance Survey, has devised a scheme of international aerial maps which has been officially adopted in France, and will probably be in other countries also.

## CHAPTER IV

### COLONIAL AVIATION

THERE can be little doubt that aviation will be of the greatest value in developing colonies. In all countries where, as a general rule, considerable distances separate inhabited settlements, means of communication are scarce, slow, and dear. In such regions, aeroplanes will soon become the most practical means of locomotion.

In regions where the building of roads and railways presents great difficulties, it will be much easier (and less costly) to erect aero-stations and supply depots. Aviation will certainly facilitate the access to desert regions where at present heat, hunger, thirst, savages, and wild beasts are such formidable obstacles.

In the French African Colonies experience has already proved the value of the aeroplane as a means of long-distance reconnaissance and pacific penetration. Military posts, separated from each other by 200 or 300 miles of desert, which a camel would take several days to cover, have been placed in regular communication with their civilised bases by the aeroplane, which can easily accomplish in a *few hours* distances which would take a week at least to traverse by other means.

Algeria, Tunis, and Morocco can thus all be easily connected with our West and Central African possessions, and valuable colonial produce,

gold, spices, etc., can rapidly reach European markets by this means.

The ravages of the war in Europe have greatly increased the importance of colonial products, and the question of their rapid transport to European markets has become increasingly important. Let us therefore examine the conditions under which regular aerial communications could be established in Africa.

Before attempting to create a regular aerial service in any region, it is essential to have some knowledge of its physical features, climatic conditions, and economic development.

A short survey of the geography of Northern and Western Africa will therefore help us to realise the technical requirements of an air line traversing these regions and the type of machine suitable; in short, to lay down what are considered the best methods of organising a colonial air service for the French Colonies.

## Notes on North and West Africa

French North Africa: Morocco, Algeria, Tunis.

A glance at the map of N. Africa will at once shew that aeroplanes will have to fly over:

Lofty mountains and high plateaux in the northern and central regions; vast desert areas in the south.

In general, and especially in the south, the distances to be flown over desert are considerable. The few existing lines of communication, caravan tracks, roads, railways, or telegraphic lines, only connect bare oases or isolated posts separated from each other often by hundreds of miles.

Traffic is very scarce, in many cases consisting

In Southern Tunisia, these bare hills are not an impassable obstacle to automobiles; and it is therefore possible to rescue aircraft that have been forced to land in these broken regions.

only of a few caravans, whose daily mileage seldom exceeds twenty.

Donkeys and mules, sometimes harnessed to light two-wheeled Arab carts, horses, and camels, are the only animals used for transport, and such means of locomotion are far too slow and costly. Pack-camels, for instance, travel in caravans at a maximum speed of twenty miles per diem, and carry some 300–350 lb., at a cost of 5 frs. (4*s.*) a day for camel and driver. The cost of transport by this means can therefore be realised.

The Sahara is marked by the absence of all vegetation which could give aviators any assistance. There are no distinguishing marks to steer by, a great handicap; there is no shelter in case of breakdown.

Under the action of the wind, the sand drifts and covers everything, and forms continually changing heaps and ridges, which are great hindrances to travel.

Finally, the complete absence of water, except at very rare wells and oases, presents a most formidable obstacle to the access to these uninhabited regions, which the Arabs, with good reason, call the "country of thirst."

But it would be a mistake to picture the Sahara as uniformly flat and desolate; it is made up of several widely differing regions: stony plateaux, oases fertilised by subterranean springs, beds of dried-up rivers, and prairies (*bleds*) clothed with scanty grass, in addition to the sandy deserts proper.

It is therefore of the utmost importance to select the most favourable routes, and to mark them out carefully and distinctly.

CLIMATE.—Speaking generally, the climate of

Northern Africa is marked by rapid changes of temperature, varying from great heat to extreme cold, which produce sudden gales and powerful atmospheric currents. It is no rare occurrence to meet with winds blowing from different directions at different heights on the same day, and over the same locality, or to experience the same phenomena in a flight of 200 or 300 miles in a straight line. Some of these winds (*e.g.* the sirocco and the simoon) are of extreme violence and produce sand-storms which penetrate everything.

Heat is also to be feared, for even winter temperatures of 60° C. (140° F.) in the sun and 50° C. (122° F.) in the shade occur. And on the uniform grey plain, vertical whirling columns of dust may often be seen in perfectly calm weather, caused by the contact of the air with the over-heated surface of the ground.

During the hottest hours of the day, violent eddies make flying very difficult; and when a machine is found to be insufficiently stable, it will be wiser to void flying during the heat of the day, in order to avoid continual jolts, fatiguing for the pilot, trying to passengers, and imposing a great strain on the aeroplane and engine.

In these circumstances, flying will preferably be undertaken in the morning and evening, and especially, if possible, during the calm tropical nights.

In West Africa the influence of the ocean and of the dense forests is felt. The climate is marked by moist heat during the rainy season from June to November, when the average temperature is 27° C. (80° F.), and heavy storms and violent gales are frequent. From November to June, which is the dry season, the temperature varies considerably in different parts; and—on the Sene-

galese coast—the easterly winds that prevail in April produce a mean temperature of 33° C. (91° F.). On the Guinea coast, hot, humid, and violent S.W. winds prevail during nine months in the year; and in Dahomey, a desiccating N.E. wind blows regularly from December to March.

These differences, occurring in the district to be traversed, will influence both the living conditions of the staff, and the type of machines chosen for the line.

Among the high mountains and on the plateaux of N. Africa, the average rainfall is smaller than in France, but torrential rains are of frequent occurrence, and these bring the annual rainfall up to 2,000 mm. (79 in.) in certain parts (Kabylia and Kroumiria), although the average annual rainfall at Paris does not exceed 580 mm. (23 in.). Such rainfalls cause sudden and dangerous floods, which submerge great tracts of land, block the roads, and sometimes deprive villages and whole localities of all means of communication with the outside world. In such cases, aeroplanes would be of the greatest use for re-establishing communication.

Clouds are practically unknown in the Sahara; but in the tropics, wet and dry seasons alternate with varying frequency and are of unequal duration in different regions. The dense equatorial forests, and the luxuriant tropical vegetation in general, occasion an exceedingly heavy rainfall.

Aircraft as at present in use in France must therefore be subjected to certain modifications before they can be employed in Africa.

In these distant regions, where supplies and spare parts are difficult to obtain, it is essential that all the parts shall be interchangeable. This

entails the *unification* of the "flying stock" in use, which must also be suited for all parts of Africa to be traversed. We shall therefore proceed to consider the working under the least favourable conditions, *i.e.* in the Sahara and West Africa, assuming that it will yield a better return in the North.

### Colonial Aircraft from a Technical Standpoint. Choice of Machines, Engines, and Hangars.

It is easy to deduce from the preceding remarks that any breakdown in such thinly-populated regions, whose inhabitants would often be hostile, and in such a bad climate, would generally be fatal to the occupants of the machine. And the sad fate of two French officers, Col. Lebœuf and Lieut. de Chatenay, who were lost in August 1916 and finally perished of fatigue and hunger in southern Tunisia, affords sufficient proof of this.

To ensure reasonable safety to flyers and to enable machines which have come to grief to be repaired and replenished, a special method of procedure must be employed.

(*a*) Aeroplanes should always undertake voyages in pairs, and should keep together so as to afford each other assistance. If one machine is forced to alight, the other could then land also, in order to render assistance, to take off the crew, and if necessary to fly to the nearest post and bring back help.

(*b*) Flying should only take place along properly marked routes, keeping as far as possible to those already existing (*e.g.* roads, railways, rivers), and these should not be deviated from. Existing caravan tracks are often invisible, and signposts

at regular intervals should be erected to mark their course.

(*c*) All machines should be provided with means of communicating with land, such as wireless apparatus, heliographs, carrier pigeons, etc.

(*d*) All the stations of an air line should be able to communicate with one another by telegraph, telephone, or wireless, so as to know exactly the hours of arrival and departure of machine from all stations.

(*e*) Proper landing places and depots of all necessary stores must be established at suitable distances. These should be provided with motor-cars, in which machines in distress can easily be reached; and they should of course afford proper shelter for aeroplanes, able to withstand all weathers.

There is no doubt that automobiles form an indispensable adjunct to aircraft; and they are destined to render most valuable services in these regions, not only from the special point of view as auxiliaries to aviation, but also as a general means of civil and military transport. For the daily limit of a single camel does not exceed forty miles, while in caravans they do not cover half that distance; moreover their carrying capacity is limited (350 lb. maximum).

Against this a suitable motor-car can travel at an average speed of 15–20 m.p.h. on a track, or even over the prairie (*bled*), with a useful load of 30 cwt.; which means 200 miles a day, and the possibility of bringing speedy help to an aeroplane, even beyond the beaten track.

The military lorries which are used by the French flying corps in southern Tunisia can travel over any ground where a two-wheeled Arab cart can go. Outside the beaten tracks, the main

obstacles that are met with consist of broad, deep ditches, heights with very steep sides, and sand-hills caused by the wind which sometimes completely block the road; but only the last are insurmountable, since the two former can generally be avoided. Moreover it must be remembered that on most important routes the track is seldom blocked by continuous masses of moving sand, but generally by narrow belts with a maximum width of a few miles. Recent experiments have proved that sand-dunes hitherto reputed impassable can be crossed by cars at about $\frac{3}{4}$ mile per hour by means of a sort of bridge which is easily transportable in the car. Finally, to ensure constant and rapid communication, all cars employed should be fitted with a wireless installation, having a radius of not less than 200 miles.

### Aircraft

It is generally believed in France that certain types of machines are quite useless for Colonial work, because the cohesive material and varnishes employed in their construction would melt under the influence of the tropical sun, because the canvas parts would rapidly relax and deteriorate under the action of heat and damp, and lastly because the wooden portions would stretch, bend, and shrink, and rapidly give way.

But these apprehensions are unfounded.

Wood, canvas, and varnish will last perfectly and perform nearly the same work as in Europe, provided that the machine is frequently and thoroughly overhauled, and above all kept always *under shelter* when not in use.

Absolutely dry and seasoned wood must, how-

ever, be used exclusively in the construction of machines for colonial use, to ensure that no shrinkages shall occur, which would put the whole machine out of gear and could only be adjusted by wholesale replacement of the parts affected. The wood used should be most carefully joined, and completely and thoroughly varnished, while the canvas can be made completely waterproof by thorough lacquering, to ensure that the whole be absolutely staunch.

The use of metal for certain parts (wing carcasses, uprights, fuselages, etc.) is clearly indicated. These must be made so as to allow for expansion, and to guard against excessive strain or refraction, which might cause certain parts to break or bend. They should also be protected by special paint, carefully applied, from the danger of erosion and the action of sand.

The choice of the machine itself will depend upon various factors (*e.g.* length of non-stop stages, nature of cargo, etc.), and will be dealt with in detail below.

### Engines

Air-cooled motors, either of the fixed or rotary type, have proved quite successful in Africa ; and the sand that penetrates nearly everywhere has not been found to interfere with their proper working to any great extent, provided that they are completely protected by airtight coverings while at rest.

The propellers must also be sheltered from the sun when it is powerful, and must not be exposed to damp for any length of time.

As regards water-cooled motors, it is better to use these only at night or during the coolest parts of

the day, unless they are fitted with a refrigerating system that will guarantee their working properly in very hot climates. And as there will be great difficulty in obtaining water to replenish the tanks, all air stations should be fitted with a portable distilling plant and with tank lorries for carrying supplies of water to aeroplanes that have had a breakdown.

The arid and deserted character of the regions to be traversed renders it above all imperative that all aircraft in use should be fitted with thoroughly reliable engines, powerful enough to deal with the violent winds so frequent in the tropics, and carrying sufficient fuel for non-stop flights of at least 250 miles.

### Shelters, Sheds, and Supply Depots

As a general rule, stone, brick, or *toub* (conglomerate) buildings are preferable to wooden sheds or canvas shelters, because they are much more durable, afford better protection against bad weather, and are generally more comfortable to live in; the latter proving almost unbearable in great heat and affording insufficient protection against cold.

It should never be forgotten that even the most comfortable tent is the least practical form of dwelling; and the natives themselves have deserted them in favour of underground habitations, or *rhorfas* (vaulted stone buildings with the thickest walls). Only the pure nomads keep their tents.

Moreover permanent buildings are in the long run at least 40 per cent. cheaper than the temporary or at best semi-permanent shelters used by the military aviation authorities.

And should the demand for speed, or the necessity of utilising a large number of military sheds no longer required by the army, oblige us to make use of such temporary buildings for the original stations, every provision should be made for replacing them, as soon as they deteriorate, by permanent structures of brick or stone. Separate sheds for each machine can easily be built, consisting of three walls properly placed with regard to the direction of prevailing winds, an iron roof covered with earth or merely made of strong canvas resting on wooden supports, and canvas or metal trellis-work doors.

### Photography

In sparsely inhabited regions where small posts and oases are of great importance, both from a military and economic point of view, a single photograph taken from a height will often furnish valuable and "concentrated" information about a whole district. Weather being generally clear in the desert, favourable results are the rule. Care should be taken that plates or films do not melt in course of developing or fixing, owing to the great heat, by keeping the solutions at a temperature not exceeding 20° C. (68° F.); and for this purpose an ice-making machine will be required.

There can be no question that aerial photography will be of the greatest service in establishing accurate maps.

### Topography

The topographical survey of little-known regions will be greatly facilitated by aviation; and by flying over them in all directions and at different

altitudes, it will be possible to make planimetric surveys from aeroplanes themselves with perfect accuracy; moreover the observers can always land when necessary to take levels. The completion and correction of existing maps should therefore be taken in hand at once and steps taken for drawing up new ones; and a special study should be made of new routes in the colonies.

The Army Geographical Department will have no difficulty in furnishing the requisite material and a properly trained staff for this purpose. Important economies will be realised by the increased speed and safety with which colonial enterprise can then be undertaken. When the number of scientific and exploring expeditions sent to the Colonies at great cost is remembered, and in many cases what scanty results they were able to achieve, in spite of great and heroic efforts, because the regions to be explored remained inaccessible owing to deficient means of transport, then the value of aviation for this purpose will be grasped.

A glance at the itineraries followed by these expeditions shows the value of their efforts and proves conclusively of what great service aviation would have been to them.

El Golea, Fort Miribel, In Salah, and many others, all these names memorable in French colonial history, were formerly mere specks lost in the vast wilderness of the desert of Southern Algeria. To-day they are in regular communication by aeroplane with each other, and with civilised Algeria, and military protection and a regular supply of provisions are thus assured.

## Aerology

The previous remarks about Northern Africa bring out the importance of aerological observation; and every flying machine should be provided with all the necessary instruments, comprising maximum and minimum thermometers, registering barometers, hygrometers, anemometers, etc.; and, in view of the great variety of atmospheric currents, devices for sending up sounding balloons should be included.

Information as to weather conditions at different stations will be transmitted by ordinary telegraph or by wireless; and the knowledge obtained as to climatic conditions, and especially as to winds prevailing in various regions, will be of great importance in the selection of machines to be employed and generally in planning and building aerial stations.

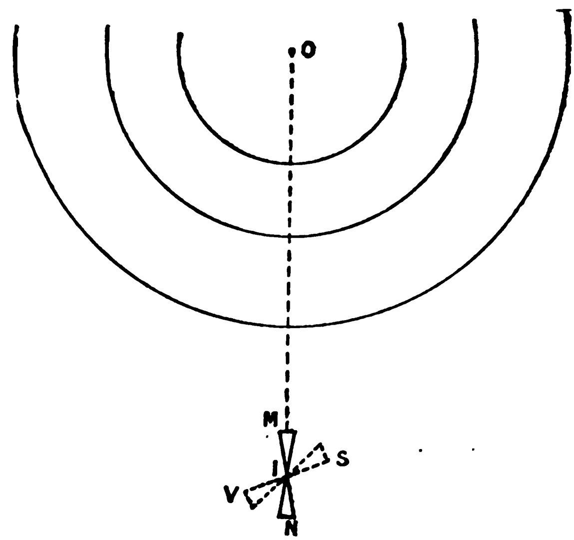
Above all registering apparatus must be provided in order to determine the "averages," a knowledge of which is indispensable for ensuring regular flights.

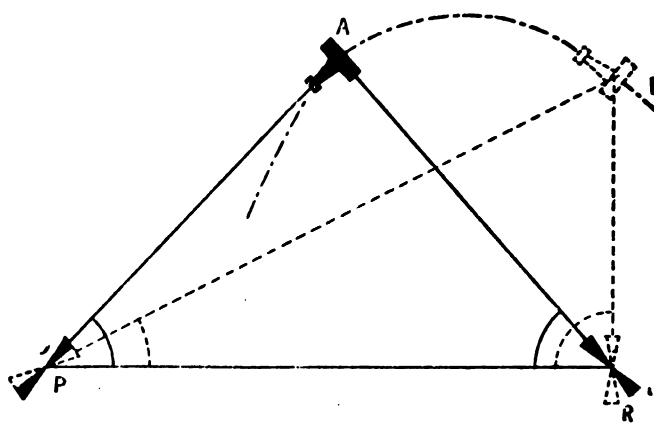
## Wireless Telegraphy

All aviation centres must naturally be connected either by already existing telegraphic lines or by wireless.

Motor-cars fitted with small wireless installations will ensure constant communication between all the units of the line, both stationary and mobile. Thus the regions traversed will be provided with a permanent network of safe and rapid means of inter-communication, which will contribute greatly to the security of travelling, both by land and by air.

All commercial aircraft should be fitted with wireless installations in the same way as vessels




are, in the interests of security. In this connection wireless will be of the utmost use, by doing

View of the desert from an aeroplane. The dark spots represent tufts of grass behind which the sand has accumulated. A good road traverses the regions which are uninhabited for hundreds of miles.

Shifting sand hills. It is difficult to discover a stranded aeroplane in these nippled, uniformly grey coloured regions.

away with the great obstacle to desert flying, namely, the absence of guiding marks. With only map and compass to steer by, pilots are at the mercy of drift, which makes them lose their way, so that on distances of 200 miles they have been driven 100 miles out of their course without any suspicion of their having been so.

Now it is possible for observers on land, and in touch with an aeroplane by means of wireless messages, to follow its course with great accuracy and to note its position on the map at any given moment, by the following method.

Let O be a wireless station, emitting waves in all directions round it; and let MN be a receiver, of the same nature as a telephone receiver; it is evident that the power and distinctness of the vibrations to which the receiver is sensitive will vary according to its position, diminishing in intensity the more it leaves the position OM, which is the direct line of transmission, to assume, for instance, the position SV.

Suppose then that A, an aeroplane, is increasing its distance from two wireless stations, P and R, remaining the whole while in telegraphic communication with them. By turning its receptor round its axis, P can determine the line of greatest wave strength felt when the aeroplane is at A, that is the line PA; R can do likewise, at the same moment, obtaining the line RA. By measuring the length of the base PR and the size of the angles P and R of the triangle APR, the exact position of the point A can be ascertained; in other words, the position of the aeroplane at a given moment.

This operation can be renewed as often as is required, and a series of points A, B, C, D, etc., will be thus obtained, making it possible to follow

the flight of the machine on the map, the two observers informing each other at once of the results of their observations by wireless or by telephone.

It is easy to conceive the great advantages of this scheme.

Not only will the exact position of the machine in flight be known at every movement, which will make it possible to find it quickly in case of breakdown and come to its assistance; but in addition the aeroplane, if fitted with receptors, can keep in constant touch with the wireless stations, which can direct its course and keep it informed of any deviation that may occur.

It may even be predicted that progress will go farther in this direction, and that automatic flight, the machine being steered at a distance by wireless, will become feasible.

Take the case of a machine fitted with a stabiliser, whose rudders are worked by electric motors themselves obedient to the influence of Hertzian rays. The machine will start by the action of its propelling machinery. It will be maintained at a certain altitude by a similar kind of mechanism to that which now serves to keep torpedoes at a certain depth under water; it will be able to move in any direction, at the will of the station from which the rays are controlled; and a special operator on land at the place of arrival will control its landing. In this way, the entire flight could be effected without a pilot. Wireless electric control could also be applied to bombing machines, not only for steering them correctly to their destination, the locality to be bombed, but also for discharging the bombs themselves at the right moment. These would be kept in place by hooks, and could be released at the right moment

by electric pressure actuated by the wireless apparatus. Meanwhile the machine itself would continue its flight under the control of the wireless operator, performing all the necessary evolutions at his command, returning on its homeward journey when all its cargo of bombs had been discharged.

Marvellous results could be achieved by such an instrument of progress, or of destruction! Long-distance aerial bombardments, automatic photography of landscape and objects within its view, aerial post, and many others. It would prove both a wonderful agent of civilisation and a terrible engine of war (if aerial warfare is not prohibited!); and towns would be practically at the mercy of such machines, much less vulnerable to anti-aircraft guns than those flown by human pilots.

We will now consider the case of two aero-stations, F and G, distant 200 miles from each


other, without any intermediate post, but connected by wireless. A simple track exists between the two points, but no other guide marks.

Before starting from either station, the speed and direction of the wind at average flying alti-

tudes will be ascertained at each station, and the consequent probable speed of the aircraft deduced.

If the latter sends out wireless calls every ten minutes, then its position in the line of route FG will be known at both stations at those moments; and in case of breakdown, entailing a cessation of the calls, its position will be known, and help can be sent from the nearest station.

If A has a speed of 200 km. (125 m.p.h.) over FG, it will cover 33 km. (20½ miles) in ten minutes. If thirty minutes elapse without a call, this will mean that an accident has occurred to the machine, or to its wireless apparatus, in the zone between km. 99 and km. 132 counting from A. But this method of ascertaining an aeroplane's position is much less accurate than the previous one suggested, and presupposes that the machine has not left its direct line of route.

MARKING THE ROUTE.—In any case, and to guard against the accidental interruption of wireless communication, the route should be clearly indicated by posts and signboards, visible from an aeroplane. Where telegraphic lines exist, the posts themselves would be most valuable for this purpose.

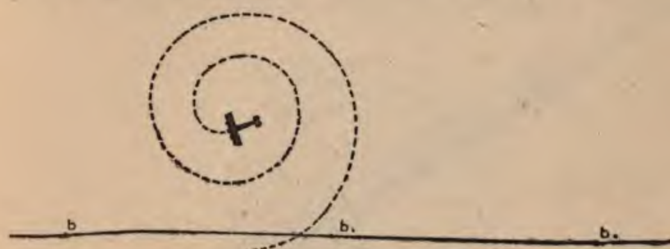
The intervals between such specially erected signposts should not be too great, so that two at once will always be visible to the pilot, enabling him thus to keep a correct course. And in any case, if this is not always feasible, the distance between the points must never be so great that the pilot of an aeroplane half-way between any two of them cannot see *at least one* of the posts.

This is absolutely essential, as without any mark to steer by he would run great risk of losing his way. Should he lose sight of the marked

Aerial photography. — In sparsely populated colonies where towns and villages are rare, and where posts and oases have great military and economic value, a single photograph will often furnish " concentrated " and important information respecting a whole district.

track completely, the following method is suggested for picking it up.

Suppose A, an aeroplane, has drifted from its proper course (the line b, $b_{,}$, $b_{,,}$). As soon as the pilot has lost sight of the signposts marking this course, he should, steering by the compass,

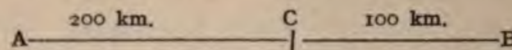



fly in circles of ever-increasing size, allowing as far as possible for drift, until he picks up the marked route.

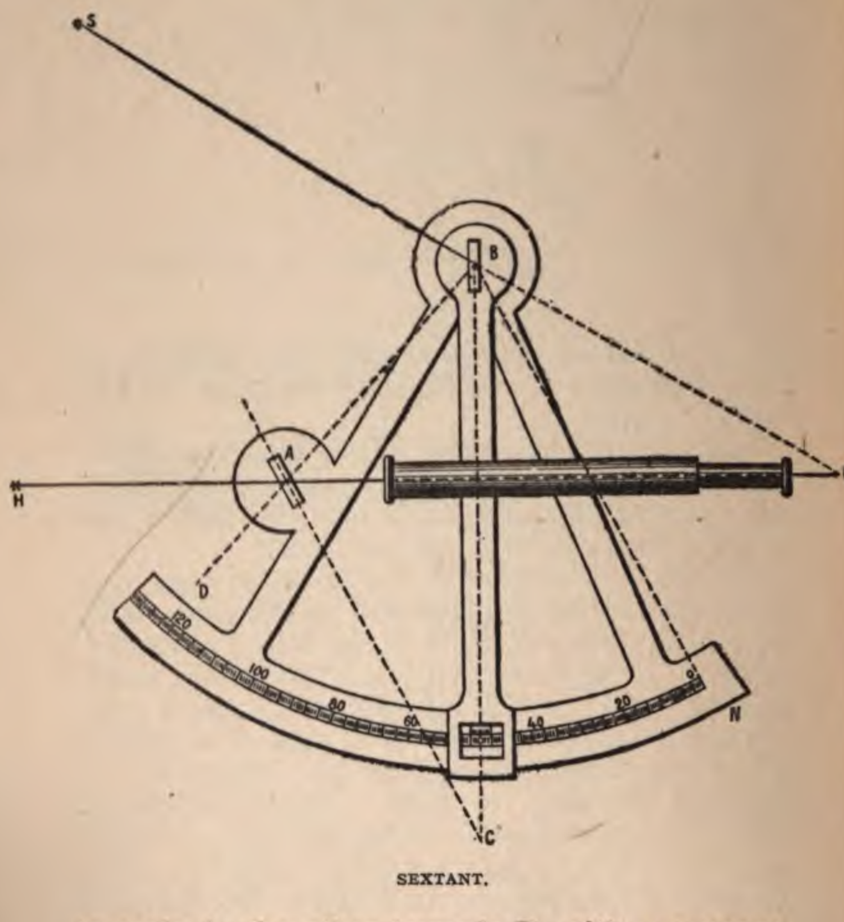
If this method fails, he will be forced to alight, take his bearings by solar observation, and allowing as accurately as possible for drift, start again at right angles to the marked track.

Carrier Pigeons.—It has already been laid down that safety in flight was an essential condition to the success of an aerial transport undertaking. Aircraft crossing the desert should therefore be provided with all possible means of communicating with their bases in case of accident; and as a safeguard against the breakdown or irregular working of their wireless apparatus, they should also carry a certain number of carrier pigeons on board, which would enable the pilot, in case of breakdown, to indicate his position, as follows: assuming that the speed of each pigeon employed is uniform (which condition can

be ensured by previous experiment), an aeroplane,




stranded at C, would release two pigeons, one

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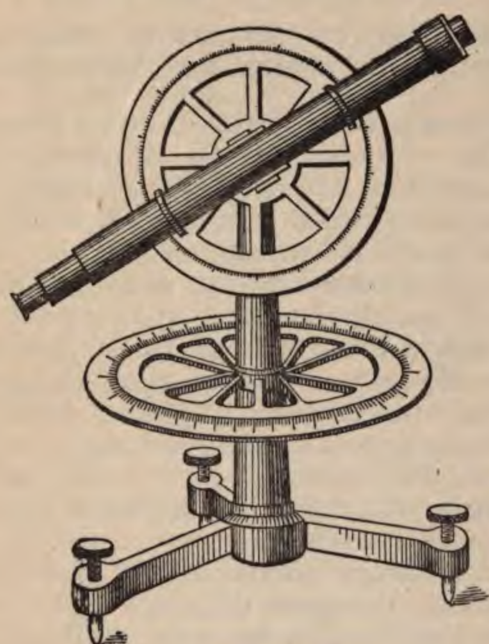
towards A, the other towards B, with a message bearing the exact time of departure. The time

when they arrive at A and B respectively will be noted, and the distance of C from these points can be calculated from the time taken (allowing for the speed of any wind).

As the inequalities of the desert will sometimes render it difficult to discover the exact position of a stranded machine, they should all be supplied



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with small balloons, inflated by compressed air, and with smoke signals and rockets, to indicate their position both by day and by night.

The pilot, or other member of the crew, will of course be qualified to take his bearings by solar observation, and will have the requisite instrument for this purpose.

# CHAPTER V

## ESTABLISHMENT OF AN AERIAL LINE BETWEEN ALGERIA AND THE FRENCH WEST AFRICAN COLONIES

We are now in a position to examine the practical possibility of organising an air service between Algeria and West Africa. To grasp the importance of the services which aviation will render in this connection, we will briefly refer to the numerous projects for a trans-Saharan railway, which have remained unrealised owing to the great natural and technical difficulties existing. Among these are the difficulty of transporting the necessary materials, the absence of water and vegetation, entailing great hardships on the constructing personnel, the existence of moving sand-hills, which under the action of the wind bury earthworks and permanent way in course of construction and interrupt existing means of communication; lastly, the mere distances to be reckoned with are considerable, since the southern termini of the Algerian railway system, Colomb-Bechar and Touggourt, are 1,700 km. (1,065 m.) and 2,100 km. (1,320 m.) distant respectively from Timbuctoo.

Up to the present, therefore, progress southwards has stopped at the northern limits of the desert, existing methods of locomotion appearing incapable of traversing these vast tracts. But aviation will enable us to cross these forbidden

regions at a bound, and thus to unify our vast African empire.

First, the most favourable natural routes for penetration must be settled; after which the real work of organising the route can be undertaken. There are two methods of attempting the latter. We can either take the type of aircraft at present in use in France, and endeavour to use it to the best advantage on a given colonial line of route; or having made a careful study of the regions to be crossed and attained, we can ask the constructors to build a type of machine adapted to the special needs of the route.

The former case will arise if for any reason (*e.g.* necessity for making use of military machines) the choice of "flying stock" is restricted. But as we are only dealing with the unlimited progress of aviation, let us consider the second case only. Not only are the majority of military planes, built for reconnaissance or bombing and in which everything is sacrificed to high speed and great carrying capacity with limited radius of action, unsuitable for use as commercial machines, which must be comfortable, be able to carry numerous passengers, and to alight at moderate speeds; but the special conditions of trans-Saharan and colonial flying must also be taken into consideration: non-stop flights of at least 250 miles over the desert, difficulty of steering, great stability required on account of gales, etc. We should therefore aim at adapting the machine to the journey, and not *vice versa*; and as this work aims at imparting practical lessons, we shall endeavour to bring these out as they arise, so that the reader may derive every advantage.

CHOICE OF ROUTES

A study of the map will reveal two possible direct routes between our North and West African Colonies.

(1) Timbuctoo-Morocco City, with a branch line from Marakech to Agadir (2,000 km. = 1,250 m.), and extension to Fez (2,300 km. = 1,440 m.).

(2) Timbuctoo-Akabli (in the oasis of Tidikel, sixty miles S.W. of In Salah), by Tanezrouft (1,200 km. = 750 m.), or by the Hoggar (1,600 km. = 1,000 m.), with branches (*a*) to Colomb-Béchar and Oran; (*b*) to El Golea or Ouargla, Laghouat, and Algiers; (*c*) to In Salah, El Biodh, Biskra, and Philippeville; (*d*) to Ghadamès and Tripoli.

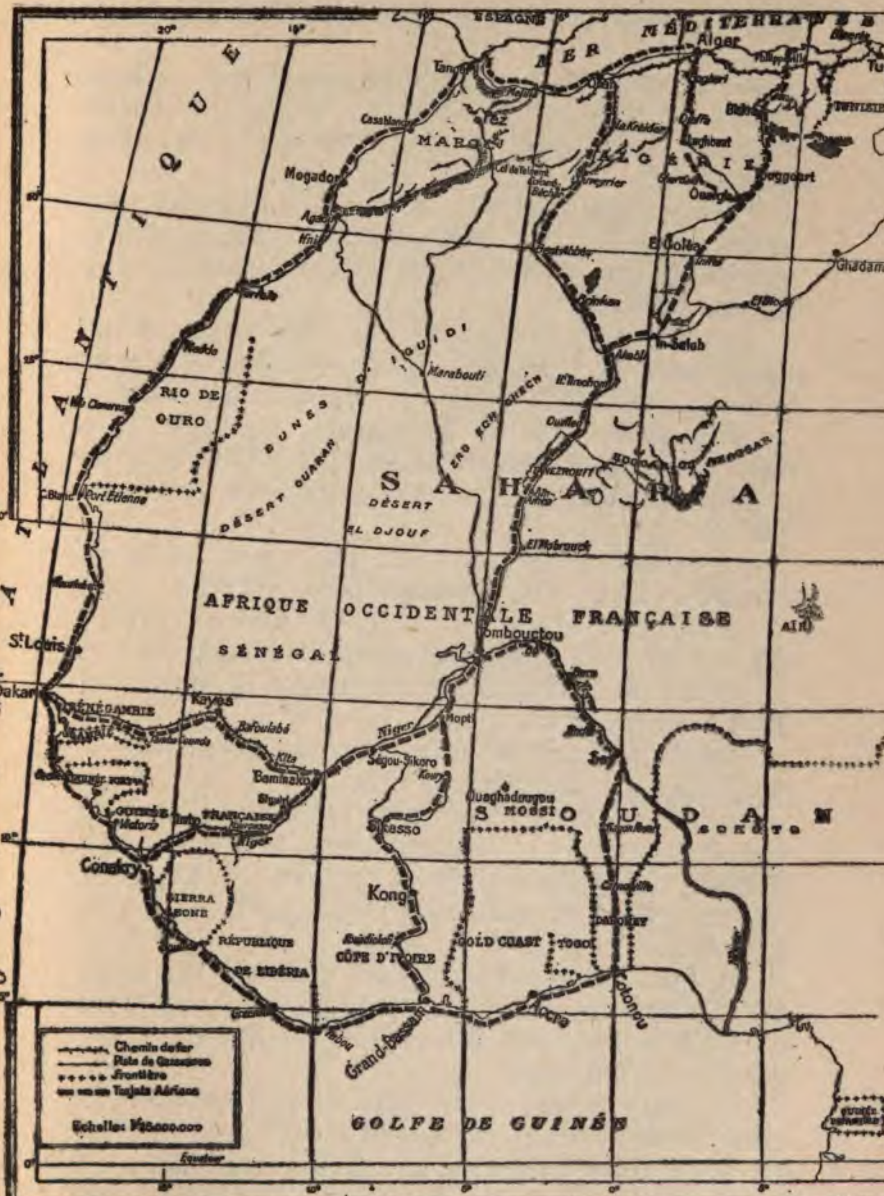
The former of these two caravan routes, the wells on which are often dried up, is distinctly excentric in relation to Algeria and Tunis, while it would traverse nothing but waterless sandy regions, or the mountainous and still unpacified territories of the great Atlas.

It is, however, probable that this route will afterwards be organised in connection with the coastal line between Dakar and Morocco, which cannot fail to be established sooner or later.

The second proposed itinerary is much more central, and serves the heart of Algeria, and the regions most completely under our influence.

It is clear that a trans-African air service falls naturally into three parts. Taking Akabli and Timbuctoo as the starting points of the 1,200 km. desert section, various subsidiary routes radiate north and south from these points, and the most suitable of these must be chosen.

For the safety and convenience of the passengers, aerial lines should as far as possible follow




*Reprinted from Jean Dargon's "L'Aviation de Demain."*

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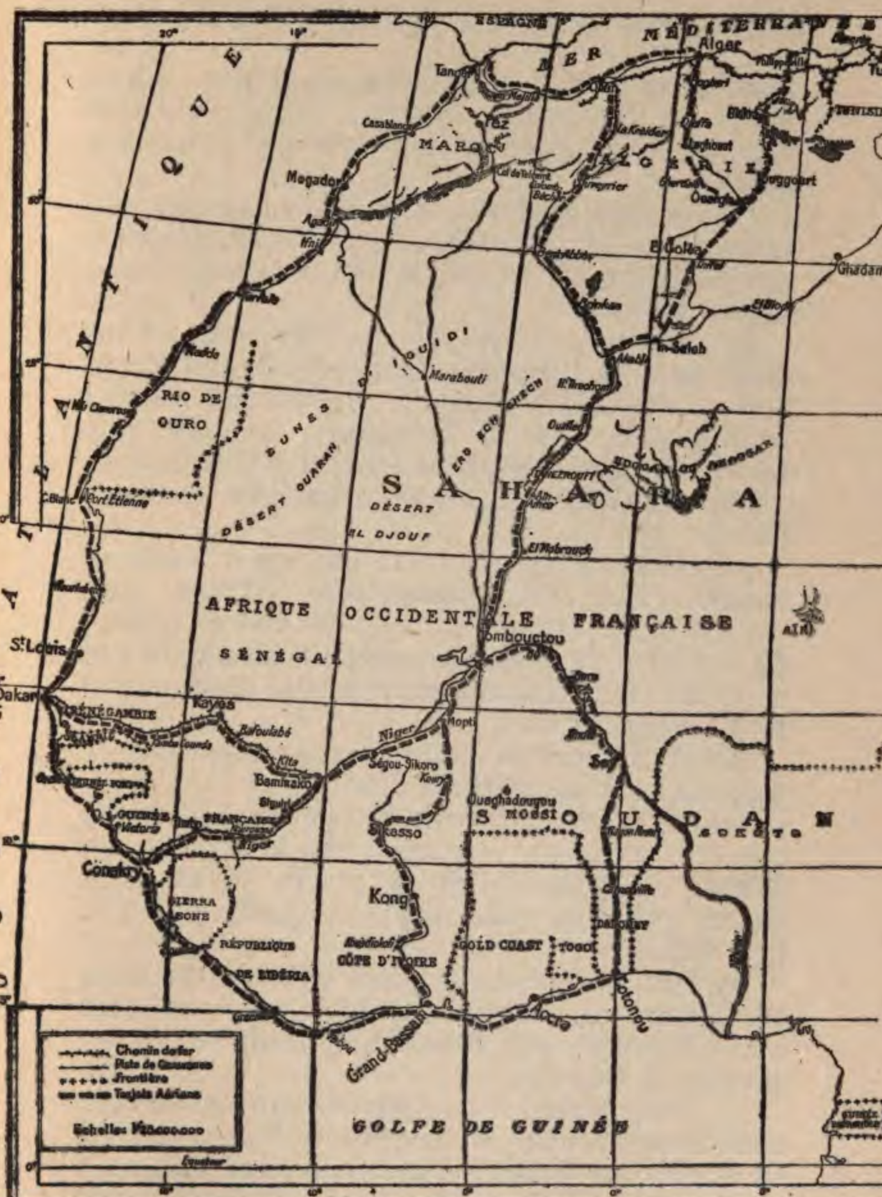


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existing tracks when crossing the desert. These moreover necessarily traverse the more fertile regions and connect the principal economic centres.

Taking these routes in order of their importance, railways, roads, caravan or other tracks, rivers, navigable or not, telegraphic lines, the chief ones are as follows:

IN NORTHERN AFRICA. (1) *Railways.*—Four main lines to the south from Algeria and Tunis. Oran to Colomb-Béchar; Algiers to Djelfa; Philippeville, Biskra, Touggourt, Ouargla (the last section under construction); Tunis to Tozeur.

The following lines and extensions are projected:

(*a*) Colomb-Béchar to Tit (20 miles north of Akabli) *via* Igli, Beni-Abbés, Kerzaz, and Tamentit; (*b*) Djelfa to Laghouat and El Golea; (*c*) Touggourt to Ouargla (under construction) and Amguid; following the route of the Flatters and Rolland expeditions.

Akabli is distant as follows from the existing or projected termini of these lines:

Colomb-Béchar, 670 km. (420 m.); Djelfa 950 km. (600 m.); Ouargla, 680 km. (425 m.); Tozeur, 1,025 km. (645 m.); Tit, 30 km.; El Golea, 450 km. (280 m.); Amguid, 390 km. (245 m.).

(2) *Roads.*—The only good existing roads in the Sahara are those from Algiers to Laghouat and El Golea, and from Philippeville to Touggourt and Ouargla.

(3) *Telegraphic Lines.*—(*a*) Oran to Beni-Abbés and Timmimoun; (*b*) Algiers to Laghouat, El Golea, and In Salah; (*c*) A transversal line connecting Djenan-el-Dar (10 m. S. of Figuig) and El Biban (S. Tunis) by Laghouat and Ouargla.

(4) *Tracks*.—From Akabli the chief caravan routes to the north are:

(*a*) Akabli-Igli-Colomb-Béchar, with numerous oases *en route*; joins the railhead at Colomb-Béchar. Work is now proceeding to make this route available for automobile traffic.

(*b*) Akabli to Ouargla *via* In Salah and Hassi-Mifel, 800 km. (500 m.). An automobile road is being made between Ouargla and In Salah.

(*c*) Akabli; In Salah; Temassimin; Ouargla (1,050 km.=660 m.). Not so direct as the preceding.

(*d*) Akabli to Ghadamès. The latter in Italian territory. To sum up, in view of the relative advantages of the above-mentioned routes, only two need seriously be taken into consideration:

(1) Akabli; Colomb-Béchar; Oran (1;400 km. =875 m.).

(2) Akabli, Ouargla, Philippeville, 1,300 km. (810 m.) or Algiers, 1,600 km. (1,000 m.).

There is little to choose between them either in point of distance or as regards convenience, safety, and facility of organisation. The ultimate choice may therefore safely be left to the companies concerned.

There will probably, almost certainly, be considerable rivalry between the various French North African ports, all aspiring to be the starting point of an aerial line, and each will be able to bring forward plausible reasons.

Thus Morocco (*i.e.* Tangier or Casa Blanca), would afford a direct route from France *via* Spain, avoiding the sea crossing.

Oran is well situated as regards a trans-Mediterranean service, for aircraft starting from Perpignan, and calling at the Balearic Isles, or hugging the Spanish coast.

Algiers, the capital of Algeria, could be connected with the other North African ports by a transversal line running parallel to the coast, and in this way concentrating the traffic.

Tunis is most favourably situated for a service from Nice, *via* Corsica and Sardinia.

But a discussion of these conflicting claims would be beyond the scope of this work, and we shall confine ourselves to a detailed examination of the two routes suggested above.

### Itineraries in Detail

I.A. Oran-Akabli.—The proposed line Oran-Colomb-Béchar-Akabli would follow the railway to Algiers at its commencement, then passing Perregaux (50 m. E. of Oran) would turn south, crossing the Atlas range, which is about 60 m. broad at this point, with a maximum elevation of 1,200 metres (4,000 ft.), and reaching Le Kreider (260 km. = 160 m.). The route would then traverse the High Plateaux, where good landing places are to be found over a distance of 100 miles, cross the Ksour range (average height 1,100 metres, maximum 2,000 metres) for a distance of 75 miles, and attain Duveyrier (240 km. = 148 m.).

At this point the route would leave the railway, which turns eastwards towards Colomb-Béchar through difficult country, to follow the track which borders the Oued Zousfana and passes through the oases of Igli, Beni-Abbés, Kerzaz, Brinkan, and Tamentit, arriving finally at Akabli after 850 km. (531 m.) over flat country.

The following are suggested as landing places and supply stations, being chosen for their economic importance and their position, and the proposed time-table would then be as follows :

TABLE I

TIME-TABLE OF NORTHERN SECTION: ORAN-AKABLI
(Without Stops)

| Places. | Distances. | | Normal speed. 150 km.p.h. | | Following wind of 60 km. | | Head wind of 60 km. | |
|---|---|---|---|---|---|---|---|---|
| | km. | m. | h. | m. | h. | m. | h. | m. |
| Oran | | | | | | | | |
| Le Kreider . . . | 250 | 156 | 1 | 40 | 1 | 11 | 2 | 46 |
| Duveyrier . . . | 240 | 150 | 1 | 36 | 1 | 8 | 2 | 40 |
| Beni-Abbés . . . | 270 | 168 | 1 | 48 | 1 | 17 | 3 | |
| Brinkan . . . | 280 | 175 | 1 | 52 | 1 | 20 | 3 | 4 |
| Akabli . . . | 345 | 216 | 2 | 18 | 1 | 39 | 3 | 50 |
| Total. . . . | 1,385 | 865 | 9 | 14 | 6 | 35 | 15 | 20 |

TABLE II

COMMERCIAL SPEED, ALLOWING FOR THIRTY MINUTES HALT AT EACH STATION

| | Distances. | | Without wind. | | Following wind. 60 km. | | Head wind. 60 k.m. | |
|---|---|---|---|---|---|---|---|---|
| | km. | m. | h. | m. | h. | m. | h. | m. |
| Oran | | | | | | | | |
| Le Kreider . . | 250 | 156 | 2 | 10 | 1 | 41 | 3 | 16 |
| Duveyrier . . . | 240 | 150 | 4 | 16 | 3 | 19 | 6 | 26 |
| Beni-Abbés . . | 270 | 168 | 6 | 34 | 5 | 6 | 9 | 56 |
| Brinkan . . . | 280 | 173 | 8 | 56 | 6 | 56 | 13 | 30 |
| Akabli . . . | 345 | 216 | 11 | 14 | 8 | 35 | 17 | 20 |

I.B. ALGIERS-AKABLI.—This line would follow the railway to the south which ends at Boghari, with extension to Djelfa and Laghouat under construction.

From Blida to Boghari the hilly region of the Tell (average height 1,400 m. = 4,700 ft.), here about fifty miles broad, must be crossed. Then comes a succession of prairies, affording good alighting grounds, for about sixty miles, followed by broken country for about 100 miles. From Laghouat the route follows the Ouargla road, *via* Ghardaia, over a level desert, then the track

to In Salah, through the absolutely uninhabited regions of the Tademait plateau. It may be noted that the direct route Ghardaia to In Salah, *via* El Golea, where the road from Algiers ends, would be 125 miles shorter.

TABLE I

TIME-TABLE OF NORTHERN SECTION: ALGIERS-AKABLI
(Without Stops)

| Places. | Distances. | | Speed 150 km. without wind. | | Following wind. 60 km. | | Head wind. 60 km. | |
|---|---|---|---|---|---|---|---|---|
| | km. | m. | h. | m. | h. | m. | h. | m. |
| Algiers | | | | | | | | |
| Laghouat (*via* Boghari, Djelfa) . . . | 350 | 218 | 2 | 20 | 1 | 40 | 3 | 54 |
| Ouargla (*via* Ghardaia) | 350 | 218 | 2 | 20 | 1 | 40 | 3 | 54 |
| Inifel. . . . | 320 | 200 | 2 | 8 | 1 | 31 | 3 | 33 |
| In Salah . . . | 360 | 224 | 2 | 24 | 1 | 43 | 4 | |
| Akabli . . . | 100 | 62 | | 40 | | 29 | 1 | 66 |
| Total . . . | 1,480 | 922 | 9 | 52 | 7 | 3 | 16 | 27 |

TABLE II

COMMERCIAL SPEED: WITH THIRTY-MINUTE STOPS

| Places. | Distances. | | No wind. | | Following wind. 60 km. | | Head wind. 60 km. | |
|---|---|---|---|---|---|---|---|---|
| | km. | m. | h. | m. | h. | m. | h. | m. |
| Algiers | | | | | | | | |
| Laghouat . . . | 350 | 218 | 2 | 50 | 2 | 10 | 4 | 24 |
| Ouargla . . . | 350 | 218 | 5 | 40 | 4 | 20 | 8 | 48 |
| Inifel. . . . | 320 | 200 | 8 | 18 | 6 | 21 | 12 | 51 |
| In Salah . . . | 360 | 224 | 11 | 12 | 8 | 34 | 17 | 21 |
| Akabli . . . | 100 | 62 | 12 | 52 | 9 | 3 | 18 | 27 |
| Total . . . | 1,480 | 922 | | | | | | |

The timing on the line from Akabli and Philippeville would be on the same system.

As we shall see, a study of these time-tables is of great interest in examining the technical requirements of aircraft to be used on these routes.

A complete and accurate map of a town can be " reconstructed " from a few well chosen snapshots of different aspects, just as well as by ordinary topographical methods.

II. Akabli-Timbuctoo.—The second portion of the journey will be the most difficult; 1,200 km. (750 m.), as the crow flies, over the Sahara. There is a choice of two routes; the first crossing the Tanezrouft region, a vast desert plain formed by a rocky surface, split and cracked in all directions by the alternate action of heat and cold. The route to be followed is a faintly marked caravan track, often losing itself on the hard rocks, or covered by the shifting sands. Nor do any hills exist in this uniformly flat and completely desolate region. A few isolated wells, at great distances from each other, and often quite dry, mark the course of a route greatly feared on account of the absolute solitude it traverses.

It is easy to understand therefore that the projectors of a trans-Saharan railway should have sought another route; and since the hills of the Great Erg on the west only offered the added obstacle of shifting sand-dunes to difficulties similar to those of the Tanezrouft route, various expeditions had investigated the more easterly route across the Hoggar. This is a considerable range, with summits attaining 2,000 m. (6,600 ft.), prolonged southward by the Aïr hills, the whole dominating all the region between the 15th and 20th degrees of latitude. A line of railway has been projected from Oran to Lake Tchad *via* Ain-Sefra, the Hoggar, and Tosay; and there is a keen controversy between the partisans of this route and that *via* Tanezrouft, which, however, makes it probable that the realisation of the project will take some time still.

In any case, the governments of Algeria and French West Africa have taken joint action for the construction of a carriage road from Algiers to Timbuctoo *via* In Salah, Tit, Hoggar, and

Bamba; this will prove of the greatest assistance to an aerial line, and it is probable that the first military aeroplanes atempting to cross the Sahara will take this route, which offers wells and supply depots at shorter intervals than the first itinerary suggested.

But it must be borne in mind that this route crossing the Hoggar is 250 miles longer than *via* Tanezrouft, and as in these sterile regions neither presents any economic advantage, it may be assumed that regular commercial aircraft will seek the shortest means of crossing the desert as soon as the progress of aviation renders this feasible.

And as the two suggested routes are very similar in their features, we will content ourselves with studying the former in detail, for the purpose of determining the most suitable type of machine.

TIME-TABLE OF CENTRAL SECTION: AKABLI-TIMBUCTOO

| Places. | Distances. | | Times. 150 km. p.h. | | Commercial speed with 30-min. stops. | | Remarks. |
|---|---|---|---|---|---|---|---|
| | km. | m. | h. | m. | h. | m. | |
| Akabli | | | | | | | |
| Tirechoumin . . | 100 | 62 | | 40 | 1 | 10 | Wells |
| Ouallen . . . | 200 | 125 | 1 | 20 | 3 | | ,, |
| Aïn-Amranen . . | 280 | 175 | 1 | 52 | 5 | 22 | ,, |
| El Mabrouck . . | 240 | 150 | 1 | 36 | 7 | 28 | Village |
| Mamoun . . . | 100 | 62 | | 40 | 8 | 38 | ,, |
| Timbuctoo . . | 280 | 175 | 1 | 52 | | | Telegraph |
| Total . . . | 1,200 | 749 | 8 | | 10 | 30 | |

III. TIMBUCTOO-WEST AFRICA.—Both on account of its geographical position and also from its economic importance, Timbuctoo is the natural destination of a trans-Saharan line, and at the same time the natural starting-point for all the routes to the various French Colonies in West

Africa, Senegal, the Guinea Coast, the Ivory Coast, and Dahomey.[1]

(*a*) *Senegal Line.*—From Timbuctoo (pop. 30,000) to Dakar (pop. 180,000), 2,300 km. (1,436 m.). Aerial lines will find it best to follow the existing means of communication, which connect the most important economic centres. This line would therefore follow the course of the Niger to Kouli-Koro, the present terminus of the railway from Dakar.

There is an existing unmetalled road, available for light carts only, between Timbuctoo and Bammako (30 m. from Kouli-Koro); and a steamer service on the Niger—making the journey in five days, but during three months of the year only, November to January.

Bammako (pop. 157,000), from its importance, is the natural starting point of the lines to Dakar and to the Guinea Coast. The former will continue, following the railway to Bafoulabé (pop. 60,000), Kayes (pop. 70,000), and Dakar.

(*b*) *Guinea Coast Line.*—Timbuctoo to Conakry (pop. 45,000). Same itinerary as the preceding as far as Bammako; the line then following the course of the Upper Niger to Kankan (pop. 40,000) the terminus of the railway from Conakry.

(*c*) *Ivory Coast Line.*—Timbuctoo to Grand-Bassam (pop. 63,000).

The line will traverse the main economic centres; Segou-Sikoro, Sikasso, Kong, and Kouadio Kofi, the future terminus of the railway from Bingerville.

This route must be very carefully marked out (with signboards, etc.) as there are no existing means of communication (roads or rivers) which can be followed.

[1] And also, it may be added, to our own West African Colonies, Sierra Leone, the Gold Coast, and Nigeria.—TRANSLATOR'S NOTE.

(*d*) *Dahomey Line.*—Timbuctoo to Cotonou. Across the desert regions of the Touareg and of Foulbé, the line will follow the course of the Niger to Say, thence turning directly to the south and following the River Ouemne as far as the coast.

A railway is projected from Cotonou to Parakou (400 km. = 250 m. inland), and the terminus of the existing telegraph line.

A transversal line connecting the two latter, and passing by Ouaghadougou in the rich and fertile Mossi district, should also be established.

TIME-TABLES

I. SENEGAL LINE

| Places. | Distances. | | Times. 150 k.m.p.h. | | Commercial time-table with 30-min. stops. | |
|---|---|---|---|---|---|---|
| | km. | m. | h. | m. | h. | m. |
| Timbuctoo | | | | | | |
| Mopti . . . . . | 370 | 231 | 2 | 28 | 2 | 58 |
| Segou-Sikoro . . . . | 350 | 218 | 2 | 20 | 5 | 48 |
| Bammako . . . . | 330 | 207 | 2 | 12 | 8 | 30 |
| Kita . . . . . | 240 | 150 | 1 | 36 | 10 | 36 |
| Bafoulabé . . . . | 210 | 131 | 1 | 24 | 12 | 30 |
| Kayes . . . . . | 200 | 125 | 1 | 20 | 14 | 20 |
| Tamba-Counda . . . | 210 | 131 | 1 | 24 | 16 | 14 |
| Dakar . . . . . | 390 | 243 | 2 | 36 | 18 | 50 |
| Total . . . . | 2,300 | 1,436 | 15 | 20 | | |

II. GUINEA COAST LINE

| Places. | Distances. | | Times. 150 km.p.h. | | Commercial time-table with 30-min. stops. | | Remarks. |
|---|---|---|---|---|---|---|---|
| | km. | m. | h. | m. | h. | m. | |
| Timbuctoo | | | | | | | |
| Mopti . . . . | 370 | 231 | 2 | 28 | 2 | 58 | Telegraph |
| Segou-Sikoro . . . | 350 | 218 | 2 | 20 | 5 | 48 | ,, |
| Bammako . . . . | 330 | 207 | 2 | 12 | 8 | 30 | ,, junct. for Dakar |
| Siguiri . . . . | 180 | 112 | 1 | 12 | 10 | 12 | Telegraph |
| Kouroussa . . . . | 150 | 94 | 1 | | 11 | 42 | ,, |
| Timpo . . . . | 240 | 150 | 1 | 36 | 13 | 48 | ,, |
| Conakry . . . . | 270 | 168 | 1 | 28 | 15 | 36 | ,, |
| Total . . . . | 1,890 | 1,180 | 12 | 36 | | | |

III. Ivory Coast Line

| Places. | Distances. | | Times. 150 km.p.h. | | Commercial timing, with 30-min. stops. | | Remarks. |
|---|---|---|---|---|---|---|---|
| | km. | m. | h. | m. | h. | m. | |
| Timbuctoo | | | | | | | |
| Mopti . | 370 | 231 | 2 | 28 | 2 | 58 | Telegraph |
| Kouri . | 210 | 131 | 1 | 24 | 4 | 52 | ,, |
| Sikasso . | 270 | 168 | 1 | 48 | 7 | 10 | ,, |
| Kong . | 270 | 168 | 1 | 48 | 9 | 28 | ,, |
| Kouadiokofi | 210 | 131 | 1 | 24 | 11 | 22 | Telegraph, terminus of projected railway from Grand-Bassam. |
| Grand-Bassam | 240 | 150 | 1 | 36 | 12 | 58 | |
| Total . | 1,570 | 979 | 10 | 28 | | | |

IV. Dahomey Line

| Places. | Distances. | | Times. 150 km.p.h. | | Commercial timing with 30-min. stops. | | Remarks. |
|---|---|---|---|---|---|---|---|
| | km. | m. | h. | m. | h. | m. | |
| Timbuctoo . . . | | | | | | | Niger |
| Bo . . . . | 250 | 156 | 1 | 40 | 2 | 10 | On the |
| Bara . . . . | 210 | 131 | 1 | 24 | 4 | 4 | ,, |
| Zinder . . . | 210 | 131 | 1 | 24 | 5 | 58 | ,, |
| Say . . . . | 150 | 94 | 1 | | 7 | 28 | ,, |
| Magou Kouari . . | 240 | 150 | 1 | 36 | 9 | 34 | Telegraph |
| Carnotville . . | 270 | 168 | 1 | 48 | 11 | 52 | ,, |
| Cotonou . . . | 300 | 187 | 2 | | 13 | 52 | ,, |
| Total . . . | 1,630 | 1,017 | 10 | 52 | | | |

## Details of Organisation

Assuming, then, that a French trans-African air service followed the route: Oran, Duveyrier, Akabli, Timbuctoo, with branches from this point to Dakar, Conakry, Grand-Bassam, and Cotonou, an air station would be established at each of these towns, as well as smaller depots at intermediate points, which would be selected according to the importance of the locality and the facilities which it offered for supply.

The principal supply depots, with large stocks of spare parts, workshops and repairing shops, would be established at Oran and Timbuctoo; the former from its position as starting point of the line and the nearest station to France, the latter on account of its central position which renders it the natural centre for all routes from West Africa.

As it is preferable that each aircraft should have its own independent complement of pilots and mechanics, who would have the sole responsibility for its navigation and upkeep, and as it would be out of the question that a single flying crew should perform the whole journey of 6,000 km. (3,750 m.), the route will be divided into three sections:

(1) Oran to Akabli.
(2) Akabli to Timbuctoo; Dakar, Conakry.
(3) Timbuctoo; Grand-Bassam, Cotonou.

Crews would only work on one sector, and would thus become thoroughly familiar with the route, a fact conducive to greater safety in operation.

When the problem of automatic stability is completely solved, pilots will probably be able to undertake much longer flights without undue fatigue and consequent danger, and aircraft fitted with very strong and thoroughly reliable engines will be able to fly continuously for several days. But this is to anticipate.

The personnel and *matériel* will form two distinct groups; the former for flying, comprising machines, pilots, and special mechanics; the latter, for the stationary service, consisting of air station staffs of all kinds, aeroplane sheds, workshops, etc., with the following organisation.

I. Flying Service.—There will be two groups of six aeroplanes each (with at least one pilot and one mechanic per machine) stationed at Oran and Akabli respectively. To maintain the service between these two places, this would be the minimum required. For, as planes will always fly in groups of not less than two (at least), this would allow three days "off" to one day on duty, a proportion which is necessary and should prove sufficient for resting flying staff and overhauling the machines.

Salvage aeroplanes would be kept in readiness at the principal stations *en route*, in sufficient numbers to replace those disabled by unforeseen accidents or by the wear and tear arising from such long flights.

But there is no absolute necessity for providing a daily service, and at the start it is probable that one weekly trip each way will prove sufficient; while the company will always be at liberty to increase the number of craft making a journey if necessary. It should be remembered, however, that in view of the great distance to be flown, the engines will not prove to be very long-lived.

It will therefore be advisable to form a reserve fleet of aeroplanes in perfect working order, with the necessary engines, equal in number to perhaps half those in regular use; with a reserve of pilots and mechanics (two per pilot), half as numerous as the reserve machines.

These aeroplanes and their crews would be stationed at the most important places, such as Akabli, Timbuctoo, Bammako, where their services would be easily available.

On the above plan, machines, engines, and crews would be stationed over the whole route somewhat as follows: Six four-engined machines at Oran,

Dakar, Conakry, Grand-Bassam, and Cotonou, twelve at Akabli and Bammako, the former the connecting point between the northern and central sector, the latter an important junction; and thirty at Timbuctoo, the starting point of all the West African branch lines. This gives a total of eighty-four machines in regular use.

There would be forty-two reserve machines distributed in the same way as above; with forty-two sets of reserve engines, the actual number of these engines depending on the size and engine power of the reserve machines.

The number of pilots and mechanics on regular duty would be the same as the number of machines, and they would be distributed on the same principle. There would be twenty-one spare pilots and twenty-one spare mechanics also, stationed on the same plan: *i.e.* six at Timbuctoo, three at Bammako, and two at each of the other stations.

II. STATIONARY SERVICES.—These would comprise a general administrative and technical staff for general management, inspection, and working, with the necessary offices and buildings. Landing places would be divided into three classes: first-class air stations, second-class air stations, and simple supply posts.

In a general way, they would be organised on the following lines:

(*a*) *First-class Stations* (*e.g.* Oran).—Staff comprising local manager of the Oran-Akabli sector; an air station-master with assistants, inspectors, controllers, etc.; and a technical staff of mechanics, carpenters, motor-drivers, etc.

The *matériel* would include a completely organised aerodrome, houses for the staff, aeroplane sheds, garages, and workshops; with a number of motor-cars.

(*b*) *Second-class Stations* would have a smaller staff, and their workshops would only be capable of dealing with current repairs.

Supply posts would merely contain sufficient fuel for replenishing machines *en route*, and provide temporary shelter. The staff would be as small as possible.

### Best Type of Machine for Colonial Work

The foregoing remarks concerning the character of the region to be traversed and the suggested timings, although somewhat wearisome, were made with the object of providing data for the purpose of evolving a suitable type of aeroplane for colonial work.

There can be no question that the most difficult and exacting portion of the journey is the central, Sahara, sector, between Akabli and Timbuctoo. There are two possible methods of crossing this stretch of sheer desert 750 miles long: either by building machines able to effect non-stop flights over this distance; or by establishing intermediate rest and supply stations.

I. If it is proposed to make use of machines capable of 750 miles non-stop flights, we must remember that the most essential quality of commercial aircraft is safety, and that the best means of ensuring this is to build machines with two or more independent engines; if one engine gives out, then the plane can continue flying with a full load on the remaining engines. For the proposed non-stop flier, let us take for instance a four-engined craft, each motor developing 200 h.p.; capable of a speed of 100 m.p.h.; and able to carry 2,200 kilos ($2\frac{1}{5}$ tons).

In the region between Timbuctoo (17° N. Lat.)

and Akabli (27° N. Lat.), the shortest day during the winter solstice is 10½ hrs. long. And allowing for the fact that in the clear air of the Sahara there is nearly always sufficient twilight to make flying possible for three-quarters of an hour before sunrise and after sunset, this gives nearly twelve hours "flying time" per day, during the shortest day. Applying the formula:

$$V = \frac{L}{T - nt} + v,$$

we find that a "real" speed of 100 m.p.h. will be necessary for crossing the desert in one day under the least favourable conditions.

But the amount of fuel required for such a journey would be:

$$45 \times 4 \times 12 = 2{,}160 \text{ kilos (over 2 tons)}$$

allowing for a fuel consumption per 200 h.p. motor of 55 kilos (121 lb.) with all four engines working at reduced speed, or $55 \times 3 \times 12 = 1{,}980$ kilos (1 ton 18 cwt.) with three engines at full speed.

Adding the weight of pilot and mechanic (160 ks. = 14 st. per person) we get:

$$2{,}160 + 160 = 2{,}320 \text{ (2 tons 6 cwt.)},$$
$$\text{or } 1{,}980 + 160 = 2{,}140 \text{ (2 tons 3 cwt.)},$$

which shows that the proposed 800 h.p. quadruple-engine machine would be incapable, *without any passengers or cargo*, of flying the distance non-stop under the most unfavourable conditions. And the ratio between speed and useful load for an 800 h.p. machine is that actually obtained under present conditions of construction; if the carrying load is increased, the speed would be correspond-

ingly less, and the craft would be unable to cover the distance in the required time.

For commercial use another type of machine must therefore be found. That is, if the first condition laid down is to be fulfilled, namely that the desert must be crossed in a *single day's non-stop flight*.

If, however, the line could be organised so that night flying were possible, then the "real" speed could be greatly reduced; for there are no existing means of locomotion to compete with (*e.g.* the railway in Europe), except the camel, which is negligible.

The only remaining factor to be considered then would be the strength of the winds often encountered in the tropics.

The aeroplane's minimum speed would then be determined as follows:

Maximum probable speed of head wind: 60 km. (38 m.) p.h.

Minimum necessary speed with such a head wind to ensure that aerial transport would offer sufficient advantages compared either with caravan traffic across the desert, or with water traffic from France, Algeria, or Morocco to West African ports (30 km. (18·6 m.) p.h.): that is, a speed of 90 km. (56 m.) p.h.

But such a comparatively low speed would have many drawbacks. In the first place, flying during the hottest hours of the day would be nearly impossible, because the slow speed of the machine would render it unstable in disturbed air; it would therefore be obliged to halt on the way, which would increase the length of the journey and necessitate the establishment of intermediate landing grounds, or at all events of temporary shelters. And on this assumption we

find that the actual time of flight from Akabli to Timbuctoo, non-stop, but with a 60 km. head wind, would be:

$$\frac{1,200}{30} = 40 \text{ hours.}$$

But this would be an impossibly long period of time, not only as regards the actual state of aviation entailing the construction of a record-breaking machine, but also from a commercial point of view, on account of the enormous weight of fuel needed for such a long flight, leaving no margin for passengers and cargo.

Lastly, the average speed of a "night machine" is still less than that of one flying *by day only* at 160 km. (100 m.) p.h.: for in twenty-four hours we find that a day flying plane would cover:

Twelve hours' flight at 160 k.p.h. = 1,920 km.; while the night flyer in nineteen hours (excluding the five hottest hours of the day) would only do $19 \times 90 = 1,710$ km.

We are therefore led to conclude, either that the speed of the "night flyer" must be increased; or that intermediate stations must be established between Akabli and Timbuctoo.

II. Akabli-Timbuctoo sector with intermediate stations.

We have just seen that in order to cover the distance between these two places, *i.e.* 750 miles, we must have machines doing 100 m.p.h. at least. And an 800 h.p. plane covering this distance non-stop would be obliged to carry more than two tons' weight of fuel and lubricant, to the complete detriment of its utility as a freight-earner.

If intermediate replenishing stations are established, then the quantity (and weight) of fuel and lubricant to be carried will diminish in proportion

to the reduction in length of the non-stop flights; in other words, in proportion to the *number* of stations existing. And these might therefore be multiplied almost indefinitely with a view to enabling the machine to carry as heavy a cargo as possible.

But, as we have already seen, in any given type of machine, speed and useful load are so related that any modification of either of these two factors would cause the other to vary inversely.

There would thus be a risk of selecting a plane of such high speed and consequent low fuel-carrying capacity, that it would have to halt, for replenishing, far too frequently for practical purposes.

A compromise must therefore be effected between these contradictory requirements, on the following basis:

If the intermediate stations between Akabli and Timbuctoo are only established near wells, it will be seen that the greatest distance between any two of them would be 280 km. (175 miles).

On the other hand, in studying the various proposed aerial routes, we noticed that the average distance between the principal centres (large towns, oases, etc.) varied between 200 and 300 miles.

Landing places situated at shorter intervals than the former, in addition to increasing the duration of the journey, would offer no advantage from a commercial point of view; but nothing would prevent an increase in their number should increase of traffic require it.

Finally, in such sparsely populated regions, it will be advisable to establish salvage stations, connected of course by wireless, and sufficiently near to each other to reduce the area of search in case of break-downs. This will probably be one

of the most important duties of the intermediate stations.

It will only be possible to employ motor-cars for this purpose over certain kinds of hard or stony ground, or over prairie land; in many parts sand-dunes would prove too great an obstacle, and in these cases camels will be employed, where air-craft alone are insufficient for salvage work.

Salvage will be organised on the following lines:

The terminal stations of any sector in which salvage machines are operating will remain in constant wireless communication with the latter, and will be duly kept informed if any unforeseen eventuality should arise.

Four kinds of accidents are likely to occur:

(1) Temporary engine trouble that can be remedied without alighting: *e.g.* one engine weakens or stops; the remaining engines are then driven at higher speed, or the spare engine is at once started, enabling the plane to continue its flight.

(2) Temporary engine trouble necessitating a landing: in such cases the aeroplane will resume its journey as soon as the trouble has been located and dealt with; and if the delay has not been a long one, the salvage stations, informed by wireless, will have no cause for anxiety.

(3) The plane forced to alight is unable to start again without help, or is the victim of a serious accident.

(4) The plane having got out of its course for some reason, loses itself in the desert.

In cases (3) and (4) the following measures will have been taken:

If the wireless is out of order, the lost flyers will take their bearings by solar observation, and dispatch carrier pigeons to both stations with

messages indicating their exact position. Salvage machines will immediately set out to find them, and will return with the passengers and cargo.

Broken-down machines will be repaired on the spot if possible; if not, taken to pieces and brought back in this way either by air, by motor-car, or on camels.

Now, assuming the worst, good camels can do about sixty miles per diem for four days, which is equivalent to a one-aeroplane stage of 240 miles, or two half-stages of 120 miles, equal to half the distance there and back separating two salvage stations. This means that passengers stranded in the desert would be certain of not remaining more than forty-eight hours without help. As regards motor-cars, they can scarcely be expected to cover more than 250 miles, over difficult desert ground, without replenishing.

There are thus many good reasons why the average length of non-stop flights in Africa should not exceed 400 km. (250 m.), and we shall determine the best type of Colonial machine on this basis.

To fly 250 miles non-stop against a head wind of 60 km. (38 m.). p.h. an 800 h.p. quadruple-engine plane flying $170 - 60 = 110$ km. (68 m.) p.h. must carry sufficient fuel for 3·38 (*i.e.* practically four hours') flight. This means: $45 \times 4 \times 4 = 720$ kilos (14 cwt.). The useful load being taken as 1,900 kilos, there remains $1{,}900 - 720 = 1{,}180$ kilos (1 ton 2 cwt.) available, or deducting the weight of pilot and mechanic (160 ks. = 3 cwt.), 1,020 kilos (19 cwt.) minimum, for cargo, etc.

Generally, however, the weight of fuel required would be less, since a steady head wind of 60 km. would be rare over such long distances; and as the air stations will keep flyers informed of meteoro-

logical conditions prevailing over the route, the amount of fuel and lubricant required for a given stage of 400 km. can be calculated before starting, as shown below:

| — | Head wind. 60 km. (38 m.). | Average weather (calm). | Following wind 60 km. (38 m.). |
|---|---|---|---|
| Average speed per hour | 110 km. (68 m.) | 170 km. (106 m.) | 230 km. (144 m.) |
| Time | 3 h. 38 m. | 2 h. 21 m. | 1 h. 44 m. |
| Weight of fuel needed | 163·5 × 4 = 654 kg. (12½ cwt.) | 105·75 × 4 = 423 kg. (8½ cwt.) | 78 × 4 = 312 kg. (6 cwt.) |
| Possible saving in comparison with the strongest head wind: | | | |
| In time | | 1 h. 17 m. | 1 h. 54 m. |
| In distance | | 218 km. (136 m.) | 437 km. (273 m.) |
| In weight of fuel | | 50 × 4 = 200 kg. (2 cwt.) | 85·5 × 4 = 342 kg. (6¾ cwt.) |

If we wish to accomplish the journey from Akabli to Timbuctoo in one day and at any time of the year, in successive non-stop flights not exceeding 250 miles each, the time necessary for three compulsory halts, about 1½ hours, must be deducted from the time available during the shortest day, about twelve hours in these latitudes, which leaves 10½ hours' flying time available. This means that the journey must be performed at a speed of 114 km. (71 m.)p.h. and that the aeroplane must have a speed of 174 km.p.h. to accomplish it it against the maximum head wind assumed.

In practice this may be reduced to 160 km.p.h., and this reduction, which assumes that 60 km. head winds will seldom be met with in practice, may be considered practicable owing to the existence of intermediate stations where a machine overtaken by nightfall can take shelter.

A 160 km. "day machine" would take four hours to cover the longest stage of 400 km. (250 m.)

against the strongest head winds (*i.e.* 160–60 × 4); and to cope with unforeseen events (deviation, loss of fuel, etc.) it will carry enough fuel for $4\frac{1}{2}$ hours' non-stop flight.

As for the "night flyer" of 90 km. speed, this must be able to remain in the air for thirteen hours (13 × 30 = 390), which entails fuel tanks of very large capacity, for several engines.

Its speed must therefore be increased so as:

(1) To reduce the size of its fuel tanks to more manageable limits.

(2) To enable it to fly properly in spite of eddies, air pockets (*i.e.* during the hot hours), and gales.

(3) To enable it to cover 400 km. in a single day under the worst conditions (*i.e.* with a 60 km. head wind).

To satisfy these requirements, a minimum speed of 120 km. (75 m.) p.h. should be sufficient; which means that there must be fuel for 6 h. 40 m. flight (say seven hours).

As the following distances would be covered: 7 × 180 = 840 km. (525 m.) in a calm, and 7 × 180 = 1,260 km. (787 m.) with a following 60 km. wind, the maximum quantity of fuel and lubricant will not always be required to cover a stage, and in such cases there will be a proportionate gain in carrying capacity.

Supposing, however, that—giving up the idea of night flying, we wish to make the journey with a "120 km. day machine"; in this case, we must examine the suggested time-tables, between Oran and Dakar for instance.

Remembering that daylight at the winter solstice does not last more than $9\frac{1}{2}$ hours between Oran and Akabli, $10\frac{1}{4}$ between Akabli and Timbuctoo, and 11 hours between Timbuctoo and Dakar, this type of machine would therefore take nearly

six days to make the journey from Marseilles to Dakar, which steamers already do in eight.

Thus, without allowing for other possible causes of delay, the journey by air would not offer a great gain in point of time.

Several types of machine, of varying speed, must therefore be used according to the time of year, or we must fall back on the "160 km. type," since it is evident that 120 km. is not fast enough for a "day machine."

The following tables give proposed timings: (1) for continuous day and night flying; (2) for flying by day only at the equinoxes; (3) for day flying during the winter solstice, over the Marseilles-Dakar route.

TABLE I

CONTINUOUS FLYING DAY AND NIGHT; WITH THIRTY-MINUTE HALTS AT EACH STATION

| Stations. | Distances. | | Times: at 120 km. p.h. | | Times: with 30-min. stops. | | Times: at 160 km. p.h. | | Times: with 30-min. stops. | |
|---|---|---|---|---|---|---|---|---|---|---|
| Marseilles | km. | m. | h. | m. | h. | m. | h. | m. | h. | m. |
| Barcelona . | 300 | 188 | 2 | 30 | 3 | 00 | 1 | 52 | 2 | 2 |
| Valencia . | 300 | 188 | 2 | 30 | 6 | 00 | 1 | 52 | 4 | 44 |
| Oran . . | 400 | 250 | 3 | 20 | 9 | 50 | 2 | 30 | 7 | 44 |
| Le Kreider . | 250 | 156 | 2 | 05 | 12 | 25 | 1 | 34 | 9 | 48 |
| Duveyrier . | 240 | 150 | 2 | 00 | 14 | 55 | 1 | 30 | 11 | 48 |
| Beni-Abbés . | 270 | 168 | 2 | 15 | 17 | 40 | 1 | 41 | 13 | 59 |
| Brinkan . | 280 | 175 | 2 | 20 | 20 | 30 | 1 | 45 | 16 | 14 |
| Akabli . . | 345 | 215 | 2 | 52 | 23 | 52 | 2 | 09 | 18 | 53 |
| Ouallen . | 300 | 188 | 2 | 30 | 26 | 52 | 1 | 52 | 20 | 15 |
| Aïn-Amranen | 280 | 175 | 2 | 20 | 29 | 42 | 1 | 45 | 23 | 30 |
| El Mabrouck | 240 | 150 | 2 | 00 | 32 | 12 | 1 | 30 | 25 | 30 |
| Timbuctoo . | 380 | 237 | 3 | 10 | 35 | 52 | 2 | 23 | 28 | 23 |
| Mopti . . | 370 | 231 | 3 | 05 | 39 | 27 | 2 | 19 | 31 | 12 |
| Segou-Sikoro | 350 | 218 | 2 | 55 | 42 | 52 | 2 | 11 | 33 | 53 |
| Bammako . | 330 | 206 | 2 | 45 | 46 | 07 | 2 | 03 | 36 | 26 |
| Kita . . | 240 | 150 | 2 | 00 | 48 | 37 | 1 | 30 | 38 | 26 |
| Bafoulabé . | 210 | 131 | 1 | 45 | 50 | 52 | 1 | 19 | 40 | 15 |
| Kayes . . | 200 | 125 | 2 | 00 | 53 | 02 | 1 | 30 | 42 | 00 |
| Tamba-Counda | 210 | 131 | 1 | 45 | 55 | 17 | 1 | 19 | 43 | 49 |
| Dakar . . | 390 | 243 | 3 | 15 | 58 | 52 | 2 | 26 | 46 | 15 |
| Total . | 5,885 km. (3,675 m.) | | 49 | 02 | (2 days 10 h. 52 m.) | | 36 | 45 | (1 day 22h. 15m.) | |

TABLE II. FLYING BY DAY ONLY: AT THE EQUINOXES

| Stations. | Distances. | | At 120 km. (75 m.) p.h. | | | At 160 km. (100 m.) p.h. | | | Remarks. |
|---|---|---|---|---|---|---|---|---|---|
| | | | Times. | Time-table. | Days. | Times. | Time-table. | Days. | |
| | km. | m. | h. m. | h. m. | | h. m. | h. m. | | |
| Marseilles . . | | | | D. 6 00 | | | D. 6 00 | | Principal air station |
| Barcelona . . | 300 | 188 | 2 30 | A. 8 30<br>D. 9 00 | | 1 52 | A. 7 52<br>D. 8 22 | | — |
| Valencia . . | 300 | 188 | 2 30 | A. 11 30<br>D. 12 00 | | 1 52 | A. 10 14<br>D. 10 34 | | — |
| Oran . . . | 400 | 250 | 3 20 | A. 15 20<br>D. 15 50 | | 1 30 | A. 13 04<br>D. 13 34 | | Aerial P.O.; telegraph |
| Le Kreider . | 250 | 156 | 2 05 | A. 17 55<br>D. 6 00 | 1 | 1 34 | A. 15 08<br>D. 15 38 | | Station; telegraph; railway |
| Duveyrier . . | 240 | 150 | 2 00 | A. 8 00<br>D. 8 30 | | 1 30 | A. 17 08<br>D. 6 00 | 1 | Salvage Station; telegraph; railway |
| Beni-Abbés . | 270 | 168 | 2 15 | A. 10 45<br>D. 11 15 | | 1 41 | A. 7 41<br>D. 8 11 | | Station; telegraph; railway |
| Brinkan . . | 280 | 175 | 2 20 | A. 13 35<br>D. 14 05 | | 1 45 | A. 9 56<br>D. 10 26 | | Station. Oasis |
| Akabli . . | 345 | 215 | 2 52 | A. 16 57<br>D. 6 00 | 2 | 2 09 | A. 12 35<br>D. 13 05 | | Aerial P.O. 120 km. from In Salah |
| Ouallen . . | 300 | 188 | 2 30 | A. 8 30<br>D. 9 00 | | 1 52 | A. 14 57<br>D. 15 27 | | Station. Well. |
| Aïn-Amranen . | 280 | 175 | 2 20 | A. 11 20<br>D. 11 50 | | 1 45 | A. 17 12<br>D. 6 00 | 2 | " " |
| El Mabrouck . | 240 | 150 | 2 00 | A. 13 50<br>D. 14 20 | | 1 30 | A. 7 30<br>D. 8 00 | | " Village |
| Timbuctoo . | 380 | 237 | 3 10 | A. 17 30<br>D. 6 00 | 3 | 2 23 | A. 10 23<br>D. 10 53 | | Aerial P.O.; telegraph |
| Mopti . . | 370 | 231 | 3 05 | A. 9 05<br>D. 9 35 | | 2 19 | A. 13 12<br>D. 13 42 | | Station; telegraph. On the Niger |
| Segou-Sikoro . | 350 | 218 | 2 55 | A. 12 30<br>D. 13 00 | | 2 11 | A. 15 53<br>D. 16 23 | | " " |
| Bammako . . | 330 | 206 | 2 45 | A. 15 45<br>D. 16 15 | | 2 03 | A. 18 26<br>D. 6 00 | 3 | Aerial P.O. Railway junction for Guinea line |
| Kita . . . | 240 | 150 | 2 00 | A. 18 15<br>D. 6 00 | 4 | 1 30 | A. 7 30<br>D. 8 00 | | Station; telegraph |
| Bafoulabé . . | 210 | 131 | 1 45 | A. 7 45<br>D. 8 15 | | 1 19 | A. 9 19<br>D. 9 49 | | " " |
| Kayes . . | 200 | 125 | 1 40 | A. 9 55<br>D. 10 25 | | 1 15 | A. 11 04<br>D. 11 34 | | Salvage station; railway |
| Tamba-Counda . | 210 | 131 | 1 45 | A. 12 10<br>D. 12 40 | | 1 19 | A. 12 53<br>D. 13 23 | | Station |
| Dakar . . | 390 | 243 | 3 15 | A. 15 55 | | 2 26 | A. 15 49 | | Principal air station |

**Table III. Flying by Day only: Winter Solstice**

| Stations. | Distances. | | At 120 km. (75 m.) p.h. | | | | At 160 km. (100 m.) p.h. | | | | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Times. | | Time-table. | Days. | Time. | | Time-table. | Days. | |
| | km. | m. | h. | m. | h. m. | | hr. | m. | h. m. | | |
| Marseilles . . | | | | | D. 7 45 | | | | D. 7 45 | | Principal air station |
| Barcelona . . | 300 | 188 | 2 | 30 | A. 10 15<br>D. 10 45 | | 1 | 52 | A. 9 37<br>D. 10 07 | | — |
| Valencia . . | 300 | 188 | 2 | 30 | A. 13 15<br>D. 13 45 | | 1 | 52 | A. 11 59<br>D. 12 29 | | — |
| Oran . . | 400 | 250 | 3 | 20 | A. 17 05<br>D. 7 15 | 1 | 2 | 30 | A. 14 59<br>D. 15 29 | | Aerial P.O.; telegraph |
| Le Kreider . | 250 | 156 | 2 | 05 | A. 9 20<br>D. 9 50 | | 1 | 34 | A. 17 03<br>D. 7 15 | | Station; telegraph; railway |
| Duveyrier . . | 240 | 150 | 2 | 00 | A. 11 50<br>D. 12 20 | | 1 | 30 | A. 8 45<br>D. 9 15 | 1 | Salvage Station; telegraph; railway |
| Beni-Abbés . | 270 | 168 | 2 | 15 | A. 14 35<br>D. 15 05 | | 1 | 41 | A. 10 56<br>D. 11 26 | | Station; telegraph |
| Brinkan . . | 280 | 175 | 2 | 20 | A. 17 25<br>D. 7 15 | 2 | 1 | 45 | A. 13 11<br>D. 13 41 | | Station. Oasis |
| Akabli . . | 345 | 215 | 2 | 52 | A. 10 07<br>D. 10 37 | | 2 | 09 | A. 15 50<br>D. 7 15 | | Aerial P.O. 120 km. from In Salah |
| Ouallen . . | 300 | 188 | 2 | 30 | A. 13 07<br>D. 13 37 | | 1 | 52 | D. 9 07<br>D. 9 37 | 2 | Station; wells |
| Aïn-Amranen . | 280 | 175 | 2 | 20 | A. 15 57<br>D. 6 30 | 3 | 1 | 45 | A. 11 22<br>D. 11 52 | | " " |
| El Mabrouck . | 240 | 150 | 2 | 00 | A. 8 30<br>D. 9 00 | | 1 | 30 | A. 13 22<br>D. 13 52 | | " Village |
| Timbuctoo . | 380 | 237 | 3 | 10 | A. 12 10<br>D. 12 40 | | 2 | 23 | A. 16 15<br>D. 6 30 | | Aerial P.O.; telegraph |
| Mopti . . | 370 | 231 | 3 | 05 | A. 15 45<br>D. 6 30 | 4 | 2 | 19 | A. 8 49<br>D. 9 19 | 3 | Station; telegraph. On the Niger |
| Segou-Sikoro . | 350 | 218 | 2 | 55 | A. 9 25<br>D. 9 55 | | 2 | 11 | A. 11 30<br>D. 12 00 | | " " |
| Bammako . . | 330 | 206 | 2 | 45 | A. 12 40<br>D. 13 10 | | 2 | 03 | A. 14 03<br>D. 14 33 | | Aerial P.O.; railway. Junction |
| Kita . . . | 240 | 150 | 2 | 00 | A. 15 10<br>D. 15 40 | | 1 | 30 | A. 16 03<br>D. 16 33 | | Station; telegraph |
| Bafoulabé . . | 210 | 131 | 1 | 45 | A. 17 25<br>D. 6 30 | 5 | 1 | 19 | A. 17 52<br>D. 6 30 | 4 | " railway |
| Kayes . . | 200 | 125 | 1 | 40 | A. 8 10<br>D. 8 40 | | 1 | 15 | A. 7 45<br>. 8 15 | | Salvage station; railway |
| Tamba-Counda . | 210 | 131 | 1 | 45 | A. 10 25<br>D. 10 55 | | 1 | 19 | A. 9 34<br>D. 10 04 | | Station; railway |
| Dakar . . | 390 | 243 | 3 | 15 | A. 14 10 | | 2 | 26 | A. 12 30 | | Principal air station |

Aerial harbour and landing ground.

Coasts are a great help to aerial navigation : they provide well marked routes, an accurate and easy means of steering, choice of alighting either on land or water, means of rescue by boat.

From these tables it would appear that the Akabli-Timbuctoo sector *can be done, either non-stop or with halts*, by a 160 km. machine, in *one* day, even against a 60 km. head wind.

But for the reasons given above, we think that it will be more advantageous to organise the line in 400 km. stages (maximum length). And we therefore arrive at the conclusion that the type of machine suitable for African work must be fitted with two or more engines, to ensure its being able to continue flying with a full load should one of them break down.

If flying both day and night is contemplated, a minimum speed of 120 km. will suffice; but if the line is only organised for day flights, its minimum speed must be 160 km.

In any case, it must be able to carry sufficient fuel to fly 400 km. (250 m.) without a stop.

Under what conditions would the staff of the desert stations live?

There is little chance of their being molested, as the few caravans which are likely to continue using the Akabli-Timbuctoo route would be at the mercy of the aeroplanes and therefore on their good behaviour.

As to dwellings, the upholders of a trans-Sahara railway have already answered the question. For, although there are, it is true, no villages in the desert, this fact is due rather to complete absence of all resources and of means of communication than on account of the climate. Life is by no means impossible for Europeans, provided that they have properly built houses, with suitable fittings. It will certainly prove much easier to erect a few groups of buildings or to construct subterranean dwellings near wells, than to build

a railway 750 miles long across the desert. And whereas caravans proceed for whole weeks without coming to any inhabited spot, and are therefore obliged to carry their entire stock of provisions with them, the air stations of the proposed line would be supplied with provisions daily by the machines maintaining the service.

Nor is the hot, dry climate of the desert unhealthy. At present loneliness and monotony, inducing melancholia, are the greatest drawbacks; these will be greatly mitigated by the existence of rapid and easy means of locomotion.

It is rather in the damp and unhealthy parts of West Africa that the problem will be acute, and there staffs will have to be relieved frequently. Aviation will in this respect offer a twofold advantage: providing an excellent fresh-air cure during actual flying, and removing the present necessity for those unduly prolonged stays in malarial districts that are so detrimental to the health of Europeans employed in West Africa.

In thus changing and improving the material and moral conditions of life in these regions, aviation will render most valuable service to the cause of civilisation.

### Cost of Establishing and Working a Colonial Air Service

We have shown that the establishment of a regular aerial service between North and West Africa is possible. Its financial success will depend mainly upon the frequency of the services provided and the quantity of goods that its aircraft can deal with.

But if success depends very largely upon the quality of the carrying material, it is also bound

up with the wealth and economic possibilities of the countries traversed; and the question arises whether the capital necessary for starting and maintaining such an undertaking will find sufficient remuneration; in other words, if a sufficient margin of profit will remain after paying all working expenses and interest on capital. To answer this question, we must know:

(1) The cost of establishing and maintaining the line.

(2) The probable number of passengers, and the probable amounts of the goods that will be carried and their value. This is a difficult problem to solve in the present circumstances, in view of the many and continually changing factors to be considered; the rise in freights which makes it so difficult to calculate with accuracy the cost of sending the necessary aviation *matériel* to these distant regions; uncertainty regarding the tranquillity of the regions to be traversed where several native risings have been caused by German intrigues; and the effects of the present European situation in the Colonies, especially in regard to wages, means of transport, purchase of lands, and frontier questions.

Any calculations can only therefore be approximate ones; but we may start by saying that Colonial lines should prove cheaper to establish than those in France.

It will seldom or never be necessary to resort to compulsory land purchase in Africa; native labour is excessively cheap (in the Touat the rate of pay for natives is 2½*d*. to 3*d*. per diem), and we have shown that salaries and wages will be one of the heaviest items in the budget of a French air company. And although the rate of pay for Europeans will be higher in Africa, on the other

hand their number will be far less, natives being employed whenever possible; stations will be fewer and less important. For all these reasons we are justified in estimating that a Colonial service will not cost half as much to organise and work as one in France.

We have seen that the price per journey in France, for a line of 500 km., with two principal stations and one secondary station, would not exceed 2,900 frs. (£116), *i.e.* 5 frs. 80 cts. per kilometre, or 4 frs. 14 cts. per kilometric ton, for a machine with a speed of 170 km. (106 m.) p.h. with a useful load of 1,400 kilos (2 tons 8 cwt.); moreover this high rate would be reduced to 3 frs. 60 (k. ton) for a 160 km. machine, and to 75 cts. (k. ton) for one of 130 km. speed. On our Colonial line we may therefore put the price at 2 frs. 90 cts. or 3 frs. (per kilo- metre), in round figures.

Under these conditions, the total cost of the journey, from Marseilles to Cotonou, *via* Oran (5,215 km. = 3,260 m.) would amount to 15,645 frs. (£625), which means 780 frs. (£31) per passenger, for a bus doing 100 m.p.h. with twenty passengers; and 312 frs. (£12 10s.) for a 75 m. machine carrying fifty.

Assuming that the companies would fix their fares on a basis of 100 per cent. gross profit per journey, and reckoning on each bus being full, we obtain the following figures:

| Route. | Distance. | Length of Journey. | | | | | Fares. | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Boat. | Aeroplane. | | | | Boat. | Aeroplane. | |
| | | | Type 120. | | Type 160. | | | Type 120. | Type 160. |
| | km. | days. | h. | m. | h. | m. | | | |
| Marseilles Cotonou | 5,215 (3,620 m.) | 18 | 52 | 20 | 41 | 35 | 1st Cl. 1,700 frs. 2nd Cl. fr. 700 | 624 frs. (£25) | 1,560 frs. (£62 10s.) |

Thus aircraft are found to be not only far speedier, but also slightly cheaper, than steamers.

This saving, which is less on the Marseilles-Dakar route, would increase very greatly for journeys to Timbuctoo and Lake Tchad, which necessitate the use of slow and expensive native methods of transport.

In view of these circumstances, there seems little danger of air-transport companies failing for lack of passengers. For it is clear that soldiers, Colonial civil servants, and merchants proceeding to or returning from West Africa and the Congo, will prefer rapid and comfortable travel by aeroplane to the slower and less comfortable existing means of locomotion by sea or land.

A considerable tourist traffic may also be reckoned on, attracted by the beauties of Algeria, the solitude and calm of the desert, the charm of its verdant oases, and the luxuriant vegetation of the tropical forests of West Africa.

## CHAPTER VI

### MARINE AVIATION

THERE is another route which could be made use of in establishing an aerial service between Algeria and West Africa, and aircraft could maintain a fast and regular service by following the Mediterranean and Atlantic coast line.

The distance between the two farthest points of such a line, Zarzis (in Tunisia) and Cotonou, is 9,000 km. (5,625 m.), more than half of which, 4,750 km. (2,968 m.) are situated in French territory; France is therefore in an exceptionally favourable position for carrying out such an undertaking.

The essential point for her to realise is the importance of the question, and to undertake its realisation without further delay.

The services of aviation can also be used to establish direct trans-oceanic communications between France and Africa, which would effect a great economy in time compared with existing steamship services.

The following table shows the route of the suggested coast line:

| Colonies. | Length of coast. | | Chief ports. |
|---|---|---|---|
| | km. | m. | |
| Tunisia (Fr.) . | 930 | 581 | Zarzis, Gabes, Sfax, Tunis, Bizerta |
| Algeria (Fr.) . | 1,160 | 725 | Bone, Philippeville, Algiers, Oran |
| Morocco (Fr.) . | 1,500 | 937 | Tangier, Rabat, Casablanca, Mogador |
| Rio de Ouro (Sp.) | 1,400 | 875 | Tarfaia, Villa Cisneros |
| Senegal (Fr.) . | 1,100 | 687 | Marsa, St. Louis, Dakar |
| Gambia (Br.) . | 90 | 56 | Bathurst |
| Portuguese Guinea | 300 | 188 | Cacheo, Bissao |
| French Guinea . | 330 | 206 | Boffa, Conakry, Benty |
| Sierra Leone (Br.) | 360 | 224 | Freetown, Soulima |
| Liberia . . | 540 | 337 | Monrovia, Greenville |
| Ivory Coast (Fr.) | 600 | 375 | Grand-Lahou, Grand-Bassam, Assinie |
| Gold Coast (Br.) . | 600 | 375 | Axim, Cape Coast Castle, Accra |
| Dahomey (Fr.) . | 90 | 56 | Grand Popo, Cotonou |

As regards trans-Mediterranean services, there are six routes to choose from:

(1) Bordeaux, West Coast of Spain, Lisbon, Morocco: 1,800 km. (1,125 m.).

(2) Bordeaux, Madrid, Morocco: 1,100 km. (687 m.).

(3) Port Vendres, East Coast of Spain, Oran: 1,000 km. (625 m.).

(4) Port Vendres, Balearic Isles, Algiers: 830 km. (518 m.).

(5) Nice, Corsica, Sardinia, Bizerta: 805 km. (503 m.).

(6) Nice, Rome, Naples, Sicily, Tunis: 1,700 km. (1,060 m.).

Excluding (1) and (6) as too far out of the way, what are the conditions to be fulfilled by the route chosen?

The factors to be considered are, amongst others; minimum distance, advantages and disadvantages of stops in foreign countries, economic importance of ports of call and delay caused by indirect route involved, etc.; the prime factor, however, from a commercial point of view will always be *safety*. But descent at sea, whether

voluntary or involuntary, involves such risks (as we shall see below) that prudence obliges us to reduce the length of flights over the open sea as much as possible; and the route, whenever possible, should follow the coast line, thus ensuring safe landing.

If with the object of establishing a purely national line, or one at all events with the minimum number of foreign landing places, we also exclude (2) and (3) there remains only the choice between (4) and (5). The first is 25 km. longer than the second, but has the advantage of Algiers, the chief North African port, as a terminus. Let us glance at the following table:

| — | Distances. | | — | Distances. | |
|---|---|---|---|---|---|
| | By coast. | Over sea. | | By coast. | Over sea. |
| | km. | km. | | km. | km. |
| Port Vendres—Spanish frontier | 10 | | Nice-Caivi . | | 175 |
| | | | West Coast of Corsica . . | 120 | |
| | | | Corsica-Asinara . | | 60 |
| Frontier-S. Felice . | 70 | | West Coast of Sardinia . | 260 | |
| S. Felice-Majorca . | | 210 | Sardinia-Bizerta . | | 190 |
| Across Majorca . | 60 | | | | |
| Majorca-Cabiera . | | 200 | | | |
| Cabiera-Algiers . | | 280 | | | |
| Total . . | 140 | 690 | | 380 | 425 |
| | 830 | | | 805 | |

For practically the same total length, therefore, the Port Vendres–Algiers route entails 265 km. (165 m.) extra distance over open sea, equivalent to about three hours' flying for a 150 km. machine under the worst conditions (80 km. head wind).

The Nice-Bizerta route, therefore, offers great advantages, but other possible routes should

not be excluded. Other factors exist, of considerable importance, which might decide the question in favour of another itinerary; for instance, the route Bordeaux-Madrid-Tangier would do away with oversea flights completely, except for the negligible distance (12 miles) over the Straits of Gibraltar. It would have the drawback of being international, it is true, but at the present stage of aviation regular trans-Mediterranean flights by commercial aircraft can scarcely be reckoned upon.

CHOICE OF MACHINES.—By the route in question the journey can be effected partly by hugging the coast, partly by flights across open sea. The longest of these would be that from Sardinia to Bizerta; 190 km. (118 m.) or 2 h. 6 m. flying time, with maximum head wind, for a 150 km. plane. Either ordinary aeroplanes or waterplanes can be employed.

If the latter could be depended on to alight safely on the water and to start from it regularly, we should choose them without hesitation in preference to the former. Unfortunately, however, they still require very careful handling in these circumstances; not only are they bad sea craft, but alighting on rough water often ends disastrously. It is true that fast machines of ordinary type sometimes come to grief when landing on rough ground; but waterplanes are very difficult to start from the water, and can only do so in calm weather. Any considerable speed on rough water produces violent oscillations and dangerous bumps caused by the waves; and should the wind also impede flight, the pilot will be well advised to give up the attempt.

In order to navigate safely and to make sure of being able to start, seaplanes should hug the

coast as much as possible, to make sure of finding smooth water to alight on if necessary. There can be little doubt, moreover, in view of the rapid progress of marine aviation since the war, that waterplanes will soon be more easily handled on the sea, and when that is the case their employment for trans-marine journeys will have every advantage. But until this time comes it will be better to use multiple-engine planes of the type already suggested, fitted with boat-shaped floats; and as machines will always fly in pairs, when any accident occurs to a plane, its consort will at once inform the nearest ship or port by wireless.

All trans-marine aerial companies must have *several fast boats* at their disposal for the immediate salvage of craft in distress.

Both on account of their small size and low elevation, aircraft stranded on the water are difficult to perceive. They should therefore be provided with small signal balloons, inflatable from tubes of compressed air, and smoke signals and rockets for indicating their position at any time.

Both land and seaplanes will at first be used; but it is already possible to foresee the construction of flying machines for use over both land and sea; these would be fitted with floats and elastic wheels, and could alight either on land or on sea, according to the needs of the moment, and thereafter proceed on their way by means of their propellers.

The final stage would be the construction of winged submarines, able to navigate under water during a storm, to remain quietly on the surface in calm weather, to fly when in a hurry, and finally to run along the ground up to the very doors of our houses! They would be cigar-shaped

and hermetically closed, with carrying wheels, wings, and fin-shaped floaters, and driven by reliable, flexible, and silent engines!

ORGANISATION OF THE ROUTE.—The route must be marked out by air stations, established as far as possible at existing sea ports, at intervals not exceeding 400 km. (250 m.), as already laid down.

The following table gives details of the proposed route:

MAXIMUM AND MINIMUM TIMES

| Ports. | Colonies. | Distances. | | Times at 150 km. p.h. | | With 30 min. halts. | | With 60 km. head wind. | | With 60 km. following wind. | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | km. | m. | h. | m. | h. | m. | h. | m. | h. | m. |
| Algiers . . | Algeria | | | | | | | | | | |
| Oran . . | ,, | 380 | 237 | 2 | 32 | 3 | 2 | 4 | 13 | 1 | 49 |
| Melila . . | Morocco (Sp.) | 280 | 175 | 1 | 52 | 5 | 24 | 3 | 6 | 1 | 20 |
| Tangier . | Morocco | 330 | 206 | 2 | 22 | 8 | 16 | 3 | 40 | 1 | 34 |
| Casablanca . | Morocco (Fr.) | 320 | 200 | 2 | 8 | 10 | 54 | 3 | 33 | 1 | 31 |
| Mogador . | ,, | 350 | 218 | 2 | 20 | 13 | 44 | 3 | 53 | 1 | 40 |
| Ifni . . | Morocco (Sp.) | 300 | 188 | 2 | | 16 | 14 | 3 | 20 | 1 | 25 |
| Tarfaia . . | Rio de Ouro (Sp.) | 380 | 237 | 2 | 32 | 19 | 16 | 4 | 13 | 1 | 49 |
| Kedda . . | ,, ,, | 280 | 175 | 1 | 52 | 21 | 38 | 3 | 6 | 1 | 20 |
| Villa Cisneros | ,, ,, | 380 | 237 | 2 | 32 | 24 | 40 | 4 | 13 | 1 | 49 |
| Port-Etienne . | ,, ,, | 400 | 250 | 2 | 40 | 27 | 50 | 4 | 26 | 1 | 54 |
| Nouakchott . | Senegal (Fr.) | 390 | 244 | 2 | 36 | 30 | 56 | 4 | 20 | 1 | 51 |
| St. Louis . | ,, ,, | 240 | 150 | 1 | 36 | 33 | 2 | 2 | 40 | 1 | 9 |
| Dakar . . | ,, ,, | 200 | 125 | 1 | 20 | 34 | 52 | 2 | 13 | | 57 |
| Cachéo . . | Port. Guinea | 370 | 231 | 2 | 28 | 37 | 50 | 4 | 6 | 1 | 40 |
| Victoria . | Fr. Guinea | 330 | 206 | 2 | 22 | 40 | 42 | 3 | 40 | 1 | 34 |
| Conakry . | ,, ,, | 230 | 144 | 1 | 32 | 42 | 44 | 2 | 33 | 1 | 46 |
| Soulima. . | S. Leone | 380 | 237 | 2 | 32 | 45 | 46 | 4 | 13 | 1 | 49 |
| Greenville . | Liberia | 360 | 225 | 2 | 24 | 48 | 40 | 4 | | 1 | 43 |
| Tabou . . | Ivory Coast (Fr.) | 200 | 125 | 1 | 20 | 50 | 30 | 2 | 13 | | 57 |
| Grand-Bassam | ,, ,, | 400 | 250 | 2 | 40 | 53 | 40 | 4 | 26 | 1 | 54 |
| Accra . . | Gold Coast | 400 | 250 | 2 | 40 | 56 | 50 | 4 | 26 | 1 | 54 |
| Cotonou . | Dahomey (Fr.) | 320 | 200 | 2 | 8 | 58 | 58 | 3 | 33 | 1 | 31 |

As in the case of the Saharan line, the air stations (for seaplanes) would be divided into three classes:

(1) Principal air stations.

(2) Second-class air stations.
(3) Supply and shelter stations.

The first would be provided with workshops able to deal with all kinds of repairs; and a squadron of reserve machines sufficient for all needs would be stationed at these points.

The second category would deal with ordinary repairs and would be provided with supply depots.

The third class would consist of simple re-victualling posts situated on long stages. With a favourable wind, it would often be unnecessary to halt at these, thus effecting a considerable saving of time; and all opportunities to do this should be taken.

For instance, suppose four towns A, B, C, D, all 400 km. (250 m.) from each other and connected by air service maintained by 150 km. machines.

Then:

| | A. | 300 km. | B. stop. | 300 km. | C. stop. | 300 km. | D. | Total time. |
|---|---|---|---|---|---|---|---|---|
| | | h. m. | m. | h. m. | m. | h. m. | | h. m. |
| Normal speed (calm) . | | 2 | 40 | 2 | 40 | 2 | | 7 20 |
| Head wind (60 km.) . | | 3 20 | 40 | 3 20 | 40 | 3 20 | | 11 20 |
| Following wind (60 km.) | | 1 25 | 40 | 1 25 | 40 | 1 25 | | 4 55 |

The difference in time over the whole distance between the highest speed and the lowest is 11 h. 20 m. – 4 h. 55 m. = 6 h. 25 m., which means nearly 1,000 km. (620 m.) at normal speed.

All stations would be connected by telegraph or wireless, and the majority should possess one or more fast motor boats for salving machines that had been forced to alight at sea, or on parts of the coast where there were no roads.

The boats themselves would also be fitted with wireless, so as to remain in touch with their bases and to communicate with planes in distress.

On the borders of the desert. — The few isolated posts which are connected by tracks are often hundreds of miles apart. In regions that have not yet been pacified, air stations will look like small forts.

In Southern Algeria, the complete absence of water, except where there are oases or wells, which are few and for between, makes these regions most difficult of access and explains their Arab name " the country of thirst ".

These measures should ensure a rapid, safe, and comfortable service.

### The Saharan and the Maritime Routes compared

In selecting an air route, one consideration comes before all others, that of safety. Nor does this depend alone on the efficiency of staff and *matériel*, on the choice of suitable landing places, on the proper marking of the route, but also on the degree in which the regions to be traversed have been pacified; for if the natives of these localities are still unsubdued, the air stations situated in their midst will run the risk of being destroyed, and their staff massacred, should native risings occur.

But in the bare regions of the Sahara, where cover of any kind is so rare, it will be difficult for rebel bands to escape the observation of scouting planes, whereas formerly the slightest depression or ridge concealed the movements of large, bodies and facilitated ambushes which the best cavalry scouts were often unable to guard against. The history of the French conquest of Algeria (and Morocco) abounds with examples of such "regrettable incidents."

In this respect, therefore, aviation will prove to be of the greatest value in exploring and pacifying hitherto unsubdued regions. In these vast expanses, where nature and man are equally hostile, aviation will be the means of ensuring rapid communication between distant posts, will enable vast stretches of country to be explored in a few hours, and by reporting enemy movements at points several days' march distant, will thus

forestall surprises and ambushes far more effectively than was hitherto possible by other means.

The establishment of regular air lines will therefore contribute to facilitate the task of the military air service, by the observations made and reports furnished by commercial aircraft in the course of their work, and by the increased facility their existence will afford of transporting reinforcements and munitions rapidly to threatened points.

Thus, although generally speaking regular aerial transport will only be established in settled or properly pacified regions, yet it may prove useful in some cases to establish air stations in hostile country, and these will of course be properly fortified, with adequate garrisons and ample stores and munitions.

Moreover the aeroplane possesses a great advantage in the fact that it entails no *continuous* line of communications, which are so easily cut, and that it can fly over obstacles which no other form of locomotion could surmount.

As regards maritime air routes, they should prove the safest in this respect; for since the suppression of piracy (at sea), marauding tribes have mostly been relegated to the interior. Therefore the employment of aircraft flying along the coast will guarantee the following advantages: a course clearly marked by the coast line itself; bearings easily taken; choice of land or sea for alighting according to the nature of the one or the state of the other; easier and more direct salvage by boat, since on land it will often be necessary to make long detours to reach a machine in distress; lastly, aerial lines running parallel to, or being the continuation of, existing steamship lines, will work in connection with the latter and will traverse frequented routes.

In this way, all kinds of produce will be quickly transported from the interior to the markets of the coast, where the chief commercial and industrial centres are generally situated; which state of things is likely to remain unaltered until the time when aircraft are able to compete on level terms with ships and railways as regards actual capacity, at the same time ensuring much greater speed. When this occurs aviation will certainly divert goods and passengers from the existing routes, both terrestrial and maritime, and produce a profound (and inevitable) revolution in the commerce of the world.

Lastly, aerial bases on the coast should prove comparatively cheap to establish, since the cost of transporting the necessary materials will be so much lower than in the case of land stations situated often at great distances in the interior.

This rapid survey should be enough to prove the immediate necessity of establishing a maritime air service plying, not only to our own (*i.e.* the French) colonies in Africa, but also to those of the other European powers on the West Coast of Africa.

A code of aerial legislation must be drawn up to regulate the harbour duties payable at foreign ports; and France will have to take care that her exports from Dahomey, for instance, are not hampered by prohibitive duties. The problem is a complex one, and is at present being studied by the French Interministerial Commission, in consultation with the other Powers concerned.

And since our North African possessions are better provided with railways and roads than those of West Africa, the trans-Saharan line will be the necessary complement to the coast route.

But whereas to ensure the satisfactory working of the former, lines must radiate from Timbuctoo to the coast in order to serve regions which become more and more productive as one approaches the sea, it would suffice, on the contrary, as in the case of existing railways, to establish embryo air services starting from the coast and converging gradually towards Timbuctoo. Their progress would keep pace with, or in some cases precede, the advance of peaceful penetration; and would be less costly and produce a quicker return.

The establishment of a permanent regular line of aerial transport will be a benefit to civilisation, and will assist the development of commerce and industry in those regions whose fertility has been recognised by numerous missions, which possess all kinds of natural resources, and whose soil contains mineral wealth in abundance.

The main question for France to consider is whether or not she shall allow herself to be forestalled by other Powers in the development of these regions.

Is it not the place of the State to encourage aerial navigation both morally and materially? And especially to assist the companies in their task of establishing aerial lines? A task of great difficulty, but full of glory for France, of great possibilities in the future.

And what a field for the energies of the hundreds of military aviators and mechanics now released by the conclusion of hostilities, and as yet unemployed! They will certainly welcome the opportunity of remunerative work, for which both their professional qualifications and the services they have rendered their country in arms eminently fit them.

None possess in a greater measure than these wonderful pioneers of progress the requisite qualities of dash, courage, and endurance for proving the continued vitality of the French race and enlarging the sphere of its influence in the world.

## CHAPTER VII

### INTERNATIONAL AIR LINES IN THE FUTURE

HAVING examined the conditions necessary for the establishment of air lines of considerable length over land and sea, we have sufficient data concerning the working of aircraft to form a judgment on the British Aerial Transport Committee's great scheme for a service to India, *via* Gibraltar, Alexandria, and Bombay.

An alternative service would follow the more direct route: London, Tarnopol, the mouths of the Ural in the Caspian, Delhi, Calcutta.

This scheme contemplates aircraft with a speed of 120 m.p.h., carrying fifty passengers, and flying by day only.

From the fact of their great speed and wide radius of action, these machines would cross regions of widely differing climate in a single flight; and as they would probably meet with atmospheric currents coming from different directions, these would tend to neutralise each other, and we may assume that the average cruising speed of the planes would be about the same as their true speed.

We should then get the following results:

| First Route. | | | | | Second Route. | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Places of call. | Distances. | | Times of stages. | | Places of call. | Distances. | | Times of stages. | |
| | km. | m. | h. | m. | | h. | m. | h. | m. |
| London | | | | | London | | | | |
| Gibraltar . | 1,750 | 1,093 | 9 | 13 | Tarnopol . | 1,850 | 1,156 | 9 | 44 |
| Malta . | 1,800 | 1,125 | 9 | 28 | Gouriev . | 1,900 | 1,188 | 10 | |
| Alexandria . | 1,550 | 969 | 8 | 9 | Bokhara . | 1,300 | 812 | 6 | 50 |
| Basoa . | 1,700 | 1,062 | 8 | 57 | Lahore . | 1,250 | 782 | 6 | 34 |
| Djask . | 1,200 | 750 | 6 | 18 | Calcutta . | 1,700 | 1,070 | 8 | 57 |
| Bombay . | 1,850 | 1,156 | 9 | 44 | | | | | |
| Total . | 9,850 | 6,155 | 51 | 49 (in 6 days) | | 8,000 | 5,008 | 42 | 5 (in 5 days) |

Bombay or Calcutta would thus be reached in less than six days, as compared with the existing times by boat of fifteen days to Bombay, and thirty-two to Calcutta (or eighteen to Calcutta *via* the Indian Overland route).

And these times (by air) can be diminished when the lines have been organised for night flying, as follows:

| First Route. | | | | | Second Route. | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Places of call. | Distances. | | Times. (1 hour at each stop). | | Places of call. | Distances. | | Times. (1 hour at each stop). | |
| | km. | m. | h. | m. | | km. | m. | h. | m. |
| London | | | | | London | | | | |
| Gibraltar . | 1,750 | 1,093 | 10 | 13 | Tarnopol . | 1,850 | 1,156 | 10 | 44 |
| Malta . | 1,800 | 1,125 | 20 | 41 | Gouriev . | 1,900 | 1,188 | 21 | 44 |
| Alexandria . | 1,550 | 969 | 29 | 50 | Bokhara . | 1,300 | 812 | 29 | 34 |
| Basoa . | 1,700 | 1,062 | 39 | 47 | Lahore . | 1,250 | 782 | 37 | 8 |
| Djask . | 1,200 | 750 | 47 | 5 | Calcutta . | 1,700 | 1,070 | 46 | 5 |
| Bombay . | 1,850 | 1,156 | 56 | 49 | | | | | |
| Total . | 9,850 | 6,155 | 2 days 8h. 49m. | | | 8,000 | 5,008 | 2 days 6h. 5m. | |

In the face of the various barriers which the war raised against free transport, both by land and by sea, the Scandinavian countries have been seriously considering the advisability of organising

aerial communications between their chief towns and ports.

A cursory glance at the map is enough to show what great services aviation could render in these countries with such a great extent of coast line, and such relatively slow and undeveloped communication by land; especially in Norway, where both the severe climate and the mountainous nature of the country place the greatest obstacles in the way of railway construction.

There is now a projected scheme for a regular international air service connecting Great Britain, Denmark, Norway, Sweden, and Finland.

A coast line about 2,500 miles in length would ring the Scandinavian Peninsula, connecting Tromsö, Bodö, Trondhjem, Bergen, Christiania, and Stockholm, with:

(1) Finland, by Abö and Helsingfors.
(2) Denmark, by Aarhus and Copenhagen.
(3) Germany, *via* Hamburg.
(4) Great Britain, *via* Stavanger and Aberdeen.

There would also be a direct line from Copenhagen to Christiania and Trondhjem, connecting the Norwegian coast and the Baltic.

The following table shows the great advantage of an air service, in point of speed, compared with lengthy sea journeys in the rough waters of the North Sea, and through fjords and straits blocked by ice in winter, or by circuitous routes through the Skagerack and Cattegat.

| Routes. | Length of sea journey. | Length of air journey. |
|---|---|---|
| Tromsö-Bodö . . . | 1½ days | 2½ hours |
| Bodö-Trondhjem . . | 1½ ,, | 3 ,, |
| Trondhjem-Bergen . . | 1½ ,, | 3 ,, |
| Bergen-Christiania . . | 1½ ,, | 2 ,, |
| Stockholm-Petrograd . . | 1½ ,, | 5 ,, (*via* Abö) |
| Copenhagen-Petrograd . | 3 ,, | 9 ,, (*via* Stockholm) |

The United States have also begun to organise air travel; and several companies for this purpose have already been formed.

Four transcontinental and three coast routes are projected. The former would have an average length of 2,500 miles; the latter, following the Atlantic and Pacific coasts, would have a total length of about 4,500 miles.

Postal aeroplanes are already in operation on certain routes, carrying passengers as well as mails.

Comfortable private touring machines are being built on a uniform plan, and we shall probably witness an even more rapid development of the aeroplane industry than in the case of automobiles.

Perhaps the day is not so far distant when the journey from Paris to San Francisco, *via* New York, will be accomplished in forty-eight hours!

The Italians have made rapid progress in aviation of late. After official trials for the carriage of mails by air between Rome and Turin in May 1917, a regular postal air service was organised between Civita-Vecchia and Terranova, in Sardinia. The 210 km. (131 m.) over open sea was covered by hydroplanes in less than two hours; and more than 200 kilos (nearly 4 cwt.) of mails are carried daily.

On September 25, 1917, an Italian military aviator carried the diplomatic bag from Turin to London, nearly 700 miles, in less than eight hours, and the letters dispatched at dawn in Turin were delivered in London before 3 p.m. the same day.

The Italian Government has made arrangements with France for establishing a regular air mail between Paris, Nice, Genoa, and Rome.

Finally, the Italians intend that a regular air service shall soon connect Sicily and Tripoli; starting from Terranova, the planes would fly

*via* the Linosa and Lampedusa isles, which would afford a refuge for hydroplanes surprised by violent sirocco (hot S.W. wind), which blows pretty frequently and with great force in this part of the Mediterranean.

Nor has Germany remained indifferent to the progress of aeronautics. Her people were not slow to recognise the enormous advantages to be derived from a powerful aerial fleet, both military and commercial; and despite the result of the war, she may still attempt to compete with England in this direction. Having shown what they were capable of in the submarine line, the Germans will certainly attempt to achieve supremacy in aeronautics.

A German "International Aerial Transport Company" has been formed for the creation of a group of main lines, from which secondary routes would radiate. The former would connect all the chief towns of Central Europe.

Those main routes crossing each other would form the backbone of the system:

(1) Hamburg, Berlin, Dresden, Prague, Vienna, Budapest, Belgrade, Sofia, Constantinople.

(2) Frankfurt, Leipzig, Dresden, Breslau, Warsaw.

(3) Karlsruhe, Stuttgart, Munich, Vienna, Budapest, Bukarest.

The Germans, with their usual practical outlook, have arranged for comparatively short stages, not exceeding 200 miles, in order to make use of the military *matériel*. The useful load, whether goods or passengers, would be as considerable as possible, relatively little fuel being carried, and the speed contemplated would be sufficient to compare advantageously with railway times. Nor

should we forget that air stations for large airships have already been in existence some years, provided with powerful beacons and in every way organised for night flying.

Thus, as soon as hostilities cease, the "Gothas" will be adapted for commercial purposes. These machines, with twin Mercédès engines of 500 h.p., can fly at 106 m.p.h. for three hours non-stop; and can easily carry ten passengers. They could thus accomplish the journey from Berlin to Constantinople, *via* Budapest, in fifteen hours; and may soon be able to do the trip between sunrise and sunset.

One of the latest types of German "Riesenflugzeuge" (giant planes) is fitted with four engines of 240 h.p. each, with a useful load of 6 tons. With fuel tanks for 5 hours' flight, it can carry 50 passengers for 600 km. (375 m.), at 120 km. (75 m.) p.h. The total weight is 14 tons, sustained by a wing area of 400 sq. metres, with a landing gear mounted on 18 wheels! In short, a regular air-bus.

Finally, the Germans were also said to be building a "colossal" fleet of giant hydroplanes, capable of crossing the Atlantic with several hundred passengers!

But though these projects may appear chimerical, it is best never to treat such schemes with undue contempt; let us remember that the best way of overcoming rivals is to study their plans and to work hard, not to despise them.

The example of the "contemptible little army" is the best proof of this.

In the presence of all these efforts, France could not think of remaining idle. Although her losses of all kinds have been greater than those of any

other belligerent, and although all her efforts were concentrated on the task of ejecting the invader, she has no intention of being left behind in the development of aviation, to the early progress of which she has contributed so largely; and on June 15, 1917, an "Interministerial Commission for Civil Aeronautics" was formed under the presidency of M. d'Aubigny, Member of the Chamber of Deputies, with M. P. E. Flandin, M.C.D., as Secretary, for developing French aeronautics in all possible ways. To entrust such a task, in the midst of war, to men whose frequently proved capacity is the best guarantee of success, shows what importance the Government attaches to the question.

The members of the commission, chosen for their special knowledge in various branches—legislation, aircraft construction, Colonial matters, postal questions, customs duties, etc.—immediately set to work, and their collaboration has already produced useful practical results, full of promise for the future.

After a study of the working conditions of an aerial transport service, the establishment of an aerial mail service was at once decided on, with a view to obtaining the necessary practical data, which will enable the advantages of the new means of locomotion to be properly appreciated.

The first steps have been the erection of postal lines from Paris to London, to Rome, to St. Nazaire, and to Corsica. And it is intended to carry out methodical trials, both over land and sea, in order to realise national and progressive development of aerial navigation.

This will be followed by schemes of greater scope, for connecting France with all the parts of her vast African empire, and for establishing a direct

line from Paris to the Far East, which would afford far more rapid means of communication than by any other route.

Nor is such a scheme Utopian. Over such great distances, the chief difficulty lies in marking the course clearly and in providing proper supply stations in sufficient number. But the existing Trans-Siberian Railway should prove sufficient for the former purpose, and it will be possible, with its aid, to establish proper supply depots in sufficient numbers along the line of route. These would be especially organised for night flying, which will prove far more feasible here than in the African or Arabian Desert. With a simple 160 km. (100 m.). p.h. machine, carrying sufficient fuel for a non-stop flight of 1,000 miles, the following times could be realised:

| Stations. | Distances. | | Intermediate times. Day flying. | Intermediate times. Day and night flying (with one hour at each stop). |
|---|---|---|---|---|
| | km. | m. | h. m. | h. m. |
| Paris | | | | |
| Warsaw | 1,450 | 906 | 9 3 | 10 3 |
| Moscow | 1,150 | 718 | 7 11 | 18 14 |
| Ufa | 1,200 | 750 | 7 30 | 26 44 |
| Omsk | 1,150 | 718 | 7 11 | 34 55 |
| Krasnojarsk | 1,300 | 750 | 7 30 | 43 25 |
| Tchita | 1,500 | 938 | 9 22 | 53 47 |
| Harbin | 1,250 | 782 | 7 48 | 62 35 |
| Tokio-Yokohama | 1,550 | 969 | 9 41 | 72 16 |
| Total | 10,450 | 6,431 | 65 16 (or 6½ days) | 3 days |

A line branching off at Krasnojarsk would connect with Pekin *via* Irkutsk and Ourga in the Gobi Desert. The distance to Pekin would be 8,750 km. (5,468 m.), which could be accomplished in 2 days and 12 hours of continuous flight, or 5 days 4 hours with day flying only.

| [illegible] | [illegible] | | [illegible] | | | |
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| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |

Coming now to the question of trans-Atlantic flight, the possibility of organising a great aerial circuit presents itself, which would be almost exclusively a French one except where it followed the eastern coast line of the States. The round trip would then be: Paris, Oran, Mogador, Dakar, Cayenne (Fr. Guiana), returning via Guadeloupe, New York, St. Pierre-Miquelon, and Brest, as follows:

| Ports of call. | Distances. | | Times of journeys (at 100 m.p.h.): Time of each stage. | | Total times with continuous flight, and 1 hour's stop at each port. | | By boat without stops, at 15 knots. | |
|---|---|---|---|---|---|---|---|---|
| | km. | m. | h. | m. | h. | m. | | |
| Paris | | | | | | | | 13 h. railway and 1½ days boat |
| Oran | 1,500 | 938 | 9 | 22 | 10 | 22 | | |
| Mogador | 1,200 | 750 | 7 | 30 | 18 | 52 | 1 | day |
| Dakar | 2,500 | 1,562 | 15 | 38 | 35 | 30 | 2½ | ,, |
| Cayenne | 4,000 | 2,500 | 25 | | 61 | 30 | 4 | ,, |
| Martinique | 2,000 | 1,250 | 12 | 30 | 75 (with 2 stops) | | 2 | ,, |
| New York (via U.S. line from Key West-Bangor) | 5,000 | 3,125 | 31 | 16 | 108 | 16 | 5 | ,, |
| St. Pierre | 1,500 | 938 | 9 | 22 | 118 | 38 | 1½ | ,, |
| Brest | 4,000 | 2,500 | 25 | | 144 | 38 | 4 | ,, |
| Paris | 620 | 387 | 3 | 52 | 148 | 30 | 10 hrs. railway | |
| Total | 22,320 | 13,950 | 138 | 30 | *i.e.* 6½ days | | *i.e.* 22 days | |

How to fly across the Atlantic in one day with an 800 h.p. four-engine machine and a favourable wind is the problem. Such a plane could carry $3\frac{1}{2}$ tons at 140 km. (88 m.) p.h.

And as we saw above, it could fly from Dakar to Natal (Brazil), about 3,000 km. (1,875 m.) in less than fourteen hours by the help of the trades. Three engines would be sufficient for flying with a full load, and, as the weight of fuel would gradually decrease, two alone would probably suffice for the last part of the journey. The average consumption may therefore be estimated as follows:

Forty-five kilos of fuel per hour per engine, *i.e.* a total of $45 \times 3 \times 14 = 1,890$ kilos (1 ton 17 cwt.). There would thus remain $3,500 - 1,890 = 1,610$ kilos (*i.e.* 3 tons 10 cwt. $-$ 1 ton 17 cwt. $=$ 1 ton 13 cwt.) available for pilot and passengers.

On the other hand, there is a difference of 17° long. between the two termini: therefore the sun sets about 1 hr. 8 m. later at Natal than at Dakar.

If the average length of the day on this route be taken as 12 hr. 15 m., and that twilight increases this about $1\frac{1}{2}$ hours, it follows that a machine leaving Dakar at sunrise will have: 12 hr. 15 m. + 1 hr. 8 m. + 1 hr. 30 m. = 14 h. 53 m. of *daylight* in which to perform he journey.

The return trip would be made by stopping at the island of St. Paul, distant about 1,000 km. (625 m.) and 2,000 km. respectively from South America and Africa. Flying at a low altitude at about 87 km.p.h. (*i.e.* 140–53, the maximum speed of the trade winds), the following times could be made:

| Places. | Distances. | | Times at 87 km. (54 m.)p.h. |
|---|---|---|---|
| | km. | m. | |
| Natal . . . . . | | | |
| St. Paul . . . . . | 1,000 | 625 | 11 hours |
| Dakar . . . . . | 2,000 | 1,250 | 22 ,, |

On the return journey the weight of fuel required, 2,970 kilos (nearly 3 tons), would only leave 530 kilos (5 cwt.) of "useful load" available.

But a study of the circular route shows that the chief difficulty resides in the stage from St. Pierre to Brest, which involves a non-stop trans-Atlantic flight of 4,000 km. And although the prevailing winds on this route are favourable, yet the possibility of a head wind must be taken into consideration, which would necessitate such a large fuel reserve that very little margin for the carriage of passengers or cargo would remain.

A 160 km. machine, with three 400 h.p. engines, each with a normal consumption of 100 kilos (220 lb.) of petrol and 10 kilos of oil per hour, would only consume on an average $80 \times 3 = 240$ kilos per hour, since it would finish the journey on two engines alone. But even to do this, for a flight of $\frac{4{,}000}{160} = 25$ hours it would require $25 \times 240 = 6{,}000$ kilos ($5\frac{1}{2}$ tons) of fuel and lubricant. And with a head wind of 60 km., and a consequent total time of $\frac{4{,}000}{100} = 40$ hours, it would require $40 \times 240 = 9{,}600$ kilos (9 tons 8 cwt.).

Such a figure is prohibitive under present conditions.

Even the Newfoundland to Ireland route, suggested in England, is probably too long: for 3,200 km. (2,000 m.) would mean 20 hours flying at 160 km., and 32 hours with a 60 km. head wind.

And in any case it will be impossible to fly the whole distance by daylight, except by alighting and heaving to on the surface, an exceedingly risky proceeding in the North Atlantic.

The case would be rather different if, giving up the idea of a direct route between Europe and America, an international line could be organised, with convenient landing places at islands *en route*.

For instance, a line starting from Lisbon, and reaching Newfoundland *via* the Azores, should prove workable in still weather or with favourable winds.[1]

TIME-TABLE OF 1,600 H.P. MACHINE
(Speed 160 km. = 100 m.p.h.)

| Stations. | Distances. | | Times and fuel consumption. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | No wind. | | Con-sump-tion. | 40-mile wind. | | Con-sump-tion. | Head wind: 40 m.p.h. | | Con-sump-tion. |
| | km. | m. | h. | m. | ks. | h. | m. | ks. | h. | m. | ks. |
| Lisbon | | | | | | | | | | | |
| St. Miguel . | 1,430 | 893 | 8 | 56 | 2,144 | 6 | 30 | 1,560 | 14 | 18 | 3,432 |
| St. Flores . | 500 | 312 | 3 | 8 | 752 | 2 | 16 | 544 | 5 | | 1,200 |
| Newfoundland | 1,950 | 1,218 | 12 | 11 | 2,924 | 5 | 51 | 2,124 | 19 | 30 | 4,680 |
| Total . | 3,880 | 2,423 | 26 | 15[2] | 5,820 | 19 | 37[2] | 4,228 | 40 | 48[2] | 9,312 |

TIME-TABLE OF 800 H.P. MACHINE
(140 km. = 88 m.p.h.)

| Stations. | Distances | | Times and fuel consumption. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | No wind. | | Con-sump-tion. | 40-mile wind. | | Con-sump-tion. | Head wind: 40 m.p.h. | | Con-sump-tion. |
| | km. | m. | h. | m. | ks. | h. | m. | ks. | h. | m. | ks. |
| Lisbon | | | | | | | | | | | |
| St. Miguel . | 1,430 | 893 | 10 | 12 | 1,377 | 7 | 9 | 965 | 17 | 52 | 2,418 |
| St. Flores . | 500 | 312 | 3 | 34 | 481 | 2 | 30 | 337 | 6 | 15 | 844 |
| Newfoundland | 1,950 | 1,218 | 13 | 55 | 1,879 | 9 | 45 | 1,316 | 24 | 23 | 3,291 |
| Total . | 3,880 | 2,423 | 29 | 41[2] | 3,736 | 22 | 24[2] | 2,618 | 50 | 30[2] | 6,553 |

These tables show that trans-Atlantic flight is quite possible with existing machines. And there can be little doubt that numerous attempts will

[1] Recent events support this view.
[2] With two stops of one hour.

be made as soon as hostilities are concluded, with the object of quickening and intensifying commercial relations with America.

And let it not be said that gales will prove an insurmountable obstacle to the development of trans-Atlantic flying. Whereas a ship, bound to the medium which sustains it, has no means of escape from the fury of the elements, aircraft, thanks to their great speed, can evade or fly from the swiftest hurricanes. And with a true speed of 200 km. (125 m.) p.h., they will soon be able to traverse the danger zone of the most violent gales (*i.e.* 100 km.p.h.); for 300 km.p.h. means 83 metres (260 ft.) per second, and the danger zone is itself in motion.

Moreover during the short time which the crossing will take, wireless messages from liners and land stations will keep aircraft constantly informed of atmospheric occurrences likely to hinder flying.

Both aircraft constructors and operating companies will aim above all at ensuring safe flying for these journeys; the reliability of the engines is therefore the prime consideration. On this route especially, the advantage of fitting machines with several engines will be apparent. These engines should be powerful and sturdy, with an ample reserve of (ascensional) power for use in the event of the stoppage of one or more of the group.

In practice, the 800 h.p. machine would seem to be the type meeting the minimum requirements of safety, speed, and carrying capacity to accomplish the task in view.[1]

[1] This problem can scarcely fail to be solved satisfactorily by the construction of machines with a variable wing surface, whose speed will increase in proportion to the diminution of the weight of fuel, and will thus be able to reduce the time of flight and the chance of accidents in a notable degree.

From its geographical situation and the position of its Colonies, France has the advantage over other countries of being able to establish direct aerial communication with Africa and the whole of America. The problem is one of the immediate future, which it is essential should be studied and solved without delay.

## CHAPTER VIII

### REGULATION OF TRAFFIC IN THE AIR

THE need for drawing up a code of aerial legislation, both for national and international use, became apparent from the first.

Whereas other vehicles of all kinds are compelled to keep to existing tracks, aircraft are free to manœuvre in space and can rapidly and easily surmount all obstacles which have hitherto constituted effective barriers to other forms of locomotion.

Both States and individuals will therefore be compelled to defend themselves, and access to their territory against these winged visitors, to whom frontiers and boundary walls are mere words.

It is probable that the existing rules governing automobile traffic and maritime navigation will form the basis of legislation concerning aerial traffic.

Experience has proved the need of making automobile drivers pass examinations, both theoretical and practical, before being allowed to drive cars, which in unskilled hands would be a source of great danger to the public. And there would probably be fewer accidents if driving licences were not given so easily.

In the case of aviation the question is even more important; for both airships and aeroplanes may easily be lost with all hands by unskilful or

foolhardy pilots, and unless properly flown they constitute a permanent source of danger to the public at large.

And as, on the other hand, the steadily increasing speed of aircraft gives them an ever wider radius of action, which means that they will soon be navigating the earth in every direction, the creation of an international pilot's licence for aircraft seems indispensable.

The tests should include various long-distance flights, under all kinds of atmospheric conditions; and should consist of several classes: for single-seaters only, for touring planes, for aerial buses, and for passenger airships. When the holder of the first class of licence had acquired the necessary skill and experience through long practice, he could obtain a licence in the next highest class, and so on; and a class of veteran aviators would be formed, just as veteran seamen exist to-day.

But it must be remembered that *age* is the greatest handicap to successful flying, and it will therefore be *essential* to subject all pilots to *periodic tests*, and to cancel the licences of those who no longer possess the requisite physical aptitude.

A second general measure is also essential: the registration of all aircraft according to a uniform international plan, with the obligation for all craft to display their national colours very distinctly both by night and day.

A difficulty at once occurs.

Even in the daytime it is not easy for a landsman to distinguish aircraft at great heights, even with powerful glasses, or in misty and cloudy weather; at night it is practically out of the question. And when engines are provided with efficient silencers—aircraft will pursue their way

on muffled wings, and by extinguishing their lights will become completely invisible.

It is clear that this state of things will have great drawbacks; and the possibilities in the way of military espionage, smuggling, or even burglary are apparent.

The following regulation should prove of great use if applied uniformly and without exceptions in all countries: the obligation to keep the apparatus for the illumination of the registration marks *under seal.*

Though such an idea may appear surprising at first sight, it is quite feasible technically; all that is necessary would be to enclose in a small sealed cage the dynamo providing the current for two or three small electric lamps, which dynamo would be worked by a screw driven by the action of wind resulting from the motion of the aeroplane. This has already been done in the case of motor cars, where the governor was sealed up to prevent the drivers from overdriving their machines and overheating the engines by keeping them working at too high a speed. This measure has proved quite satisfactory; and is not the case of gas and electric meters in private houses analogous?

With the above system, any stoppage of the lighting apparatus could be at once detected by the proper authorities, stationed at the various points, such as aerial police stations, aero-stations, public aerodromes, frontier customs, etc., where spare parts are obtainable.

And to meet the case of unforeseen breakdowns, the illuminating system can be installed in duplicate; and owing to its low power, this should present no obstacle either in respect of space required, weight, or price. It will be compulsory to allow the system to be examined whenever the

inspectors demand it, just as a chauffeur must now present his licence for examination and endorsement when required to do so.

The obligation to keep the registration mark or number of aircraft always perfectly visible is even more important than in the case of motor-cars, whose numbers are so often hidden by mud or darkness.

It is essential that the state, whose business it is to ensure order and safety, should take a firm stand in this question from the beginning; and that aviators should not be allowed to form bad habits, which they would later have great difficulty in overcoming.

The establishment of an efficient aerial police force must therefore be considered; composed of special men mounted on extra-rapid machines capable of overhauling all delinquents, and being invested with the authority to insist on immediate descent when considered necessary, to examine suspicious craft, or those openly disregarding the registration laws. These police machines would be fitted with powerful searchlights, wireless apparatus in tune with police stations, and photographic apparatus suitable for their special work.

Aerial inspection stations would be established at various points, especially on hills, near frontiers, and on the coast.

These would serve the purpose of observatories, beacons, shelters for police planes, and customs stations.

An entirely new organisation for this purpose will have to be created.

For watching the frontiers and preventing spying near fortifications, it will probably be necessary to establish "prohibited areas." But how are their limits to be fixed?

As the field of observation increases with altitude, the minimum distance within which aircraft will be allowed to approach these areas must be such that it is impossible, in the clearest weather, to make any useful observation with the help of the most powerful instruments.

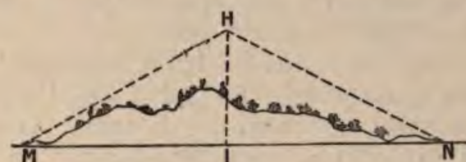
Finally, customs stations will be established on each side of the frontier and along recognised routes, where all aircraft coming from abroad will be obliged to land on arrival.

To prevent smuggling by dropping dutiable goods from the air, all aircraft bound for a foreign country will be examined before their departure as well as at their destination, and the cargo on arrival will be checked from the manifest.

In the case of private machines, not licensed to carry goods, some such rule as the following may be put into force: any machine alighting for any reason outside the limits of recognised official landing places will not be allowed to depart before having its papers endorsed by the nearest competent local authority. This would enable all the requisite information regarding the machine itself and its crew to be obtained, and a report drawn up when necessary respecting its reasons for landing on unauthorised ground.

Such measures of course necessitate the creation of regular *aircraft papers*, both national and international (*cf.* home trade and foreign trade ships' articles), with a full description of the craft, its official numbers of registry, etc. Such papers would contain spaces for recording incidents on the journey by the pilot (as on a ship's log), and others for endorsements by competent authorities (as on a ship's articles). In addition, the owners and pilots of private machines would possess their own individual flying certificates.

Other regulations in the interests of public safety will also be made, *e.g.* prohibition of flying over towns and other thickly populated districts at less than a certain height, or within a certain radius. These limits would be fixed as follows:




MI = MN = 4 km. ($2\frac{1}{2}$ m.); HI = 666 metres (717 yds.).

The above diagram represents a town viewed in perspective, MN being its greatest width.

If a machine is planing at $\frac{1}{6}$, the minimum height above the town from which it can safely plane down beyond its limits (M and N) is such that $h = \frac{MN}{12}$

If MN = 8 km. (5 m.), the aeroplane must not fly over the town at less than:

$$\frac{8}{12} = 666 \text{ metres in calm weather.}$$

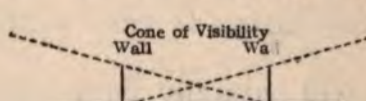
This rule will naturally be a uniform one for all aeroplanes, whether good or bad volplaners; just as there now exists a uniform maximum speed for all kinds of automobiles in certain places. And in the near future we may see alongside the existing notices, with this legend, "Speed limit for motor cars ten miles," new horizontal notice boards with "Aircraft, minimum height 1,200 metres" on their upper surface in large letters. Unless a more drastic regulation, indifferent to the reproach of aerophobia, which aviators

will not fail to level at it, entirely prohibits flying above all urban areas.

And will private property be left quite at the mercy of impertinent scrutiny from the air? A satisfactory and practical solution of this question is unfortunately by no means easy to arrive at.

There is little doubt that the Government, always on the look out for fresh sources of revenue, would be quite ready to grant big landlords the right to put up notices bearing the legend, "Flying prohibited over this land," on the payment of a duty; but both the delimitation of "private air spaces" and the enforcement of the prohibition to traverse them would seem to offer almost insuperable difficulties in practice.

Suppose aircraft are forbidden to cross an aerial zone, of either specified or unlimited height, and whose base consists of a given area of land (*e.g.* a park); all well and good. But even the enforcement of this measure would not suffice to protect the park from aerial observation, since an aeroplane flying round the outside of the imaginary walls could still overlook the property as follows:




The problem thus appears to be insoluble. And in any case the proprietor's rights will be more or less affected, and except in certain special cases, such as military areas, the "freedom of the skies" would seem to be assured.

To avoid as far as possible the numerous disputes which are bound to occur between aviators and farmers in the case of forced landings in fields under cultivation, would it not be possible to

draw up a return in each department[1], showing the value of different crops according to the season?

Wheat, barley, hay, beetroot, etc., would be valued at so much per square yard; and all that would then be necessary would be to verify the area of damage and pay compensation accordingly. This wise plan has already been adopted by the French military authorities in the case of army pilots and has been found to work well. Its adoption in all cases would certainly lessen the work of the courts.

And also, in order to protect aerial travellers from profiteers in case of breakdown, and to prevent the latter from raising exorbitant claims harmful to the development of flying, it would be as well to lay down that damages claimed in respect of loss of cattle, damage to crops, etc., arising from accidents, should not exceed the current value of the damaged object, reckoned on the departmental schedules. Such a precaution may appear excessive to some, but not to those whose misfortune it has been to fall (from the sky) into the hands of greedy "landsmen." There will certainly be a profitable field for insurance companies in these cases; and it will be their task to protect the interests of unfortunate private aviators against imposition.

Composed of safe and powerful aircraft, protected by wise legislation and by agreements enjoying universal assent, the air fleets of the future will set forth to conquer the world.

Aviation cannot fail to be the means of a profound transformation of the existing conditions of life; and with its assistance humanity will extend the conquests already made by science.

[1] Or county.

We can already look forward to the day when flying machines, driven by engines of infinitely greater power than at present, will be capable of rising vertically and remaining stationary in the air, and will attain speeds of 200 or 300 miles an hour.

# APPENDIX I

## HELICOPTERS

HELICOPTERS possess considerable advantage over ordinary aeroplanes, in being able to ascend or descend vertically without the necessity of running along the ground before taking off, or after alighting.

Moreover, helicopters can not only fly at any speed (*i.e.* the lowest), but also possess the faculty of hovering or remaining stationary in the air, whereas an ordinary plane is only sustained by its high speed.

The first experiments with helicopters (butterflies) were made in France as long ago as 1784.

In the latter half of the nineteenth century, numerous demonstrations and trials took place without any great practical result, the existing engines not being sufficiently powerful, in proportion to their weight, to lift machines of any size.

In 1903 Col. Renard read a paper before the French Academy of Science, in which he showed that, thanks to the internal-combustion engine, a practical solution of the problem had become possible.

But it has been found that other difficulties exist. For the motive power of a helicopter must be sufficient not only to *raise* it from the ground, but also to propel it through the air, which entails not only great increase in the power (and consequent weight) of the engine, but also involves mechanical complications in the structure of the engine itself. These include engines working at different speeds, the necessity of overcoming the double gyratory movement by using two screws revolving in different directions on an identical axis of rotation, propellers working at different inclinations in order to raise

the machine obliquely with a single set of engines, this also involving the use of compensating rudders and elevators. Lastly, the sustaining and lifting mechanism must be absolutely reliable and easy to work, if vertical descent is to be kept under the necessary control to prevent accidents due to violent contact with the ground.

Aeronauts use the guide rope, throw out ballast, and open the gas valve to ensure landing safely and easily; in the case of helicopters, since the air becomes denser

BUTTERFLY-SHAPED HELICOPTER, WITH TWO PROPELLERS AND A PARACHUTE.

and has therefore greater sustaining power as they descend, the means of alighting safely must consist in a progressive reduction of the power of the sustaining mechanism, so that its action shall exactly equal the force of gravity at the moment of contact with the ground. This result can be attained either by reducing the rotary speed of the horizontal propellers, by diminishing their sustaining area, or by changing their angle of incidence.

But whatever method is used must be absolutely reliable and even in its working, since the maintenance

of the helicopter in the air depends entirely upon this, and the slightest breakdown would cause a fall involving fatal consequences. All machines of this kind should therefore be provided with efficient parachutes, opening either at will, or automatically when the vertical speed reaches a certain limit; unless a system of inclined planes can be devised, rendering volplané descents possible, as in the case of aeroplanes. This solution is perhaps the most hopeful one.

A HELICOPTER OF THE FUTURE.

Be that as it may, the almost complete cessation of experiments with helicopters for some years past is due to several causes, of which the chief were the great progress in aeroplane construction between 1908 and 1914, and the urgent necessity during war of perfecting those types of machine which were already efficient in 1914.

But there can be little doubt that experiments in this line will soon be renewed, and it may be hoped that they will be crowned with success, and will mark the attainment of a fresh stage in the conquest of the air.

# APPENDIX II

## VARIATIONS OF TEMPERATURE

ASSUMING that meteorological conditions are not subject to variation, and given the absence of wind, temperature as indicated by the thermometer diminishes progressively with increase of altitude.

The law governing this diminution as accepted by meteorologists is that "temperature decreases 1 degree (C.) every 180 metres (600 ft.)." This law remains true up to 600 metres (2,000 ft.), but at higher altitudes it cannot be stated with the same accuracy. Moreover this height, corresponding to a fall of 1 degree (C.), varies considerably according to the condition of the air, and whether it is "dry," "damp," or "saturated" with humidity.

In the case of absolutely dry air, the increase of height required to lower the temperature 1 degree (C.), according to thermodynamic formulæ, is 101 metres; in "damp" air it varies between 102 and 106 metres; finally, if the air is "saturated" the figure may be much higher.

The cooling of the atmosphere, as greater altitudes are reached, is due to the fact that it expands as the pressure decreases, and consequently becomes colder; the highly compressed air produced in the laboratory manifesting exactly the contrary tendency.

In the case of atmospheric disturbance, this law of decrease may prove temporarily quite inoperative, for observations made at high altitudes have even furnished examples of "inversions" of temperature; which in these exceptional cases actually *rose* with the increase of altitude. The lower air strata are then colder than the higher; and this phenomenon, which may sometimes

be observed in the spring, is the cause of those late frosts so disastrous to fruit-trees.

In comparing the temperature of different places situated at different altitudes, care must be taken only to work with temperature "reduced to sea level."

All the necessary factors for doing this are to be found in the "International Meteorological Tables," together with a simple formula for calculating the result.—(*From A. Berget's "Physique du Globe."*)

## APPENDIX III

### LENGTH OF DAY AT DIFFERENT LATITUDES

On the following diagram (Fig. 1) let O be a sphere rotating on its axis PP′ (the line of the poles); QQ′ the plane of the equator (circle perpendicular to PP′).

Then a "meridian" is any circle passing through the points PP′, and a "parallel" any circle parallel to the equator.

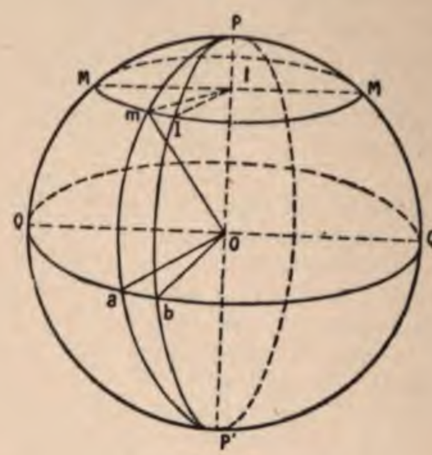



FIG. 1.

Taking the points $l$ and $m$, then the arc $ma$ represents the "latitude" of the point $m$; this latitude is measured in degrees and fractions of a degree, and is said to be "north" or "south" according as it is situated in the northern or southern hemisphere. If we take a "meridian of origin" P$m$P′ passing through $m$ (in France and Great

Britain the meridian of Greenwich has been adopted), then the longitude of a point $l$ will be measured by the

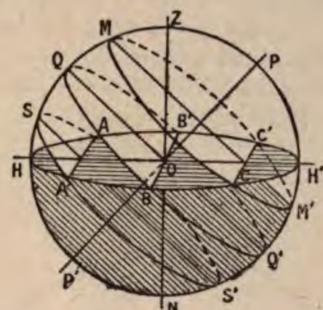



FIG. 2.

APPARENT DAILY MOTION OF THE SUN AT PARIS.

HH', horizon; PP', axis of celestial poles; SAS', sun's motion on December 21 (winter solstice),; A, sunrise at that date; QBQ', sun's motion on March 21 and September 23 (equinoxes); B, sunrise at those dates; MCM'E', sun's motion on June 21 (summer solstice); C, sunrise, C', sunset, at that date.

arc *ab*, which is "east" or "west" according to its position in relation to the "meridian of origin."

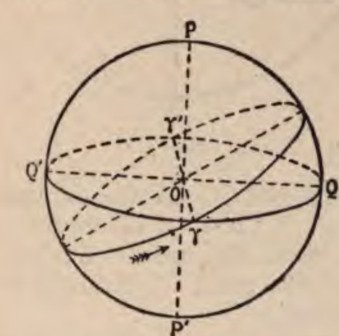



FIG. 3.

ECLIPTIC AND SUN'S APPARENT ANNUAL MOTION.

QQ', celestial equator; PP', line of the poles; YY', ecliptic (the arrow indicates the direction of the sun's apparent motion).

The latitude and longitude of a point determine its exact position on the globe.

In observing the sun's apparent motion at Paris, it is

found that the arc which it describes does not always start from the same point. In summer, when the days are longer, the sun rises nearer the north, while in winter, when the days are shorter, it rises farther to the south. During six months it revolves above the celestial equator QQ′, during the other six months below it (Fig. 2). By marking its daily position on the celestial sphere, a circle is formed inclined at an angle of $23^\circ\ 27'$ to the equator; this circle is the ecliptic (Figs. 3 and 4).


FIG. 4.

The solstices (O and O′) are the extreme points of the sun's motion, $23^\circ\ 27'$ above or below the equator.

The point O, which the sun reaches on June 21, is the summer solstice; the point O′, attained on December 21, the winter solstice.

Two other remarkable periods are those at which the sun reaches the points $\gamma$ and $\gamma'$, situated in the plane of the equator. These constitute the equinoxes, autumn, September 23, spring, March 21. The parallels of the celestial sphere passing through the points O and O′ are called tropics, because they mark a period when the sun begins to revolve in the contrary direction; and they are known as the tropic of Cancer and Capricorn respec-

tively, from the names of the constellations which the sun apparently traverses at the time.

*Inequality of Day and Night.—Seasons.*—The fact that the ecliptic is not in the same plane as the equator, but is inclined at an angle of 23° 27′ is a fact of prime importance, involving incalculable geographical consequences. For it is owing to this fact that days and nights are of unequal length, and that seasons occur on the surface of the earth. This has already been shown to be the case in mean latitudes; to demonstrate that it is equally true at any point of the earth's surface, let us represent the earth as it appears to the sun at the solstices and at the equinoxes (Figs. 6, 7, and 8).

At these periods the sun's movement follows the celestial equator; and Fig. 6 shows that the earth's rotation will bring every point situated on it into the illuminated and darkened circles successively. Night and day will be of equal length all over the world; and the word "equinox" is derived from this.

At the summer solstice, when the sun has attained the farthest point, its rays form an angle of 23° 27′ with the equator (Fig. 7). The circle of illumination (C D′), instead of passing through the line of the poles as at the equinox, forms an angle of 23° 27′ with this line; and is tangent at C and D′ with the parallels C D and C′ D′, called the Polar Circles.

In this position the earth's motion will *not* bring all the points of its surface into the illuminated and darkened circles in succession. As shown on Fig. 7, all the points situated on the segment C P D, known as the Arctic Circle, will not experience darkness, whilst the contrary will be true of the points situated in C′ P′ D′, called the Antarctic Circle. All other portions of the earth's surface experience days and nights of unequal duration according to their latitude. It should also be noticed that the circle of the equator is the only one that is divided into equal halves by the circle of illumination, and which alone in consequence has nights and days of equal length, *i.e.* twelve hours. From the equator to the Arctic Circle, the length of the day goes on increasing until it attains

twenty-four hours; and from the equator to the Antarctic Circle it diminishes until it is only o hours.

At the winter solstice conditions are exactly the opposite to what they were at the summer solstice; and a glance at Fig. 8 is sufficient to demonstrate this. The lengths of the days are the same as at the summer solstice, but the figures for the northern hemisphere become those for the southern, and *vice versa*.

Between the equinoxes and solstices there are periods of gradual transition, so that from the autumn to the

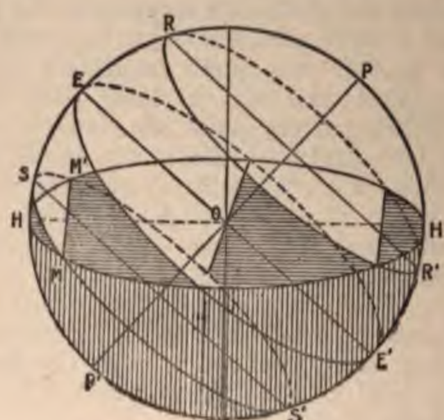



FIG. 5.

vernal equinox the days are always longer than the nights in the southern hemisphere; and during the period from the vernal to the autumn equinox the contrary is the case.

Since day is a period of increasing warmth, and night one of increasing cold, this shows why the seasons are due to the inclination of the ecliptic. The hot season is the period of long days at all points of the earth's surface, the cold season one of long nights. Since the unequal length of day and night increases according to latitude, the seasons necessarily become more and more marked the farther regions are distant from the equator. The

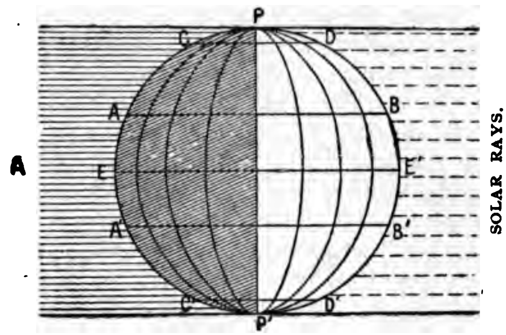



FIG. 6.

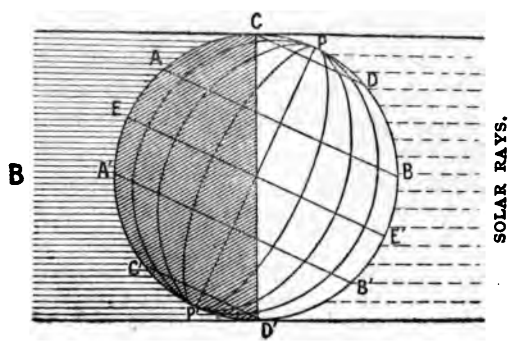



FIG. 7.

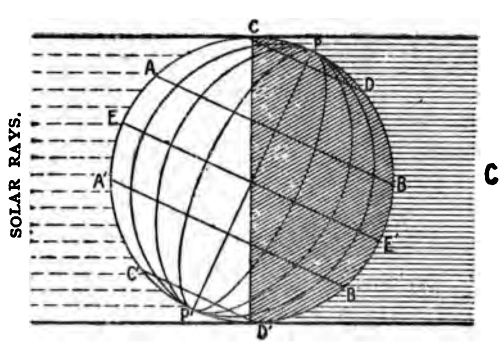



FIG. 8.

rotundity of the globe alone involved the conceptio of climatic zones, the inclination of the ecliptic provid the theoretical means of determining their limits.

Between the parallels of 23° 27′ north and 23° 2 south latitude extends what is known as the " tropical zone, where the length of day and night is not subje to much variation, this being also true of the temperatu of the atmosphere. North and south of the tropical zo are situated two "temperate" zones extending as far the Polar Circles, in which the length of day and nig varies considerably, without, however, ever attaining t maximum length of twenty-four hours, and in whic consequently the temperature is subject to great vari tions in the course of the year. Lastly, beyond the Pol Circles stretch the coldest regions of the earth, owing t the fact that the nights are the longest, attaining length varying from twenty-four hours to six months, accordin to the latitude.—(*From Martone's " Traité de Geographi Physique d'Emm."*)

## APPENDIX IV

### METEOROLOGICAL PREVISIONS

*Observations to be Centralised.*—Apart from "local" symptoms, which may serve as guides in foretelling changes of weather, there are many "general" symptoms, deductions from which, made use of on a logical system, add considerably to the possibility, not indeed of predicting weather with certainty, but at least of foreseeing its probable character for a short time ahead.

With this object, a general meteorological service was organised in 1855 on the initiative of the French astronomer Leverrier, which collects the information gathered by a large number of widely scattered stations, at one central observatory. This "Bureau Central Météorologique" in France is entrusted with the duty of publishing all these reports received daily by telegraph, in the form of synoptic charts, and of informing all seaports and the chief agricultural centres, by telegraph, of the nature of the weather forecasts made from the mass of information it receives.

This work is performed almost perfectly in the United States by the Weather Bureau, and the observations taken for purposes of transmission are all made "exactly at the same time," based on the same meridian. In France, unfortunately, the information received at the Central Bureau often concerns observations taken four or five hours previously, during which time profound atmospheric changes may already have occurred; but nevertheless the Bureau has proved of the greatest benefit.

*Weather Charts.*—The results obtained are published daily on two charts, one dealing with barometric pressures, the other with variations of temperatures. In addition

to the isobars and isotherms, the charts also show other lines numbered in Roman numerals; these are the lines joining localities where identical variations of pressure have occurred during the day (*e.g.* 15 millimetres); they are called lines of "equal barometric variation." The temperature charts also carry lines of "equal thermometric variation," otherwise known as "isonomes." They are of great importance in foretelling the arrival of sudden gales, as will be shown.

It is by comparing the synoptic charts with those of the preceding day that the weather next day can be foretold with more or less accuracy; the forecasts thus made are telegraphed to the coast, and in cases when heavy gales have been predicted they have frequently prevented disasters at sea.

*Foretelling Storms.*—It must be admitted that the geographical position of Western Europe is most unfavourable for predicting stormy weather with any certainty.

As we have already explained, nearly all gales come from the west and strike our shores (France and England) as they arrive from the Atlantic. For a long time it was thought that telegraphic warning could be sent from the States; but a glance at the chart indicating the main atmospheric circuits will show that *more* than half of these storms have their origin in the North Atlantic.

The most westerly of the European stations must therefore be interrogated. There are three: the Azores, unfortunately, are not much use, because as they are near the region of maximum Atlantic pressure, few storms actually strike them. Iceland, admirably situated, is unfortunately unconnected by submarine cable. We must therefore fall back on Valentia alone, until a proper high-powered wireless station has been erected at Reykjavik.

*Symptoms announcing Depression.*—In addition to isobaric and isonomal lines, barometric charts also show the varying force of the wind.

The first thing to do, on examining the neighbourhood of Valentia on the chart, is to look at the isobars: any

tendency to a fall in this advanced region nearly always indicates bad weather to come. If, in addition to this, the lines of equal variation surround Valentia concentrically, then not only bad weather but a storm is approaching.

The way in which the direction of the wind varies round this advanced station must also be carefully studied on the daily charts, in order to see whether this gyratory movement is in accordance with Dove's law. If continual light southerly winds, changing gradually to south-west, are observed, then a gale may be predicted with certainty.

Partial depressions due to the splitting up of a large area of depression must also be carefully watched. These segments often follow one other at short intervals; while one has already burst over Central Europe, a second is in course of arriving at Valentia.

Lastly, the return of a continued rise indicates that the high pressure zone has been re-established and the atmospheric currents in the Atlantic circuit regularised.

*Local Symptoms. Cloud Observations.*—Apart from a study of the charts, it is important to make careful observations at each station of those meteorological phenomena which can furnish information as to the probable course of the weather. Sailors, who depend entirely upon such data, are known as excellent weather prophets.

The observation of the clouds is of the highest importance.

Near the northern edge of the great atmospheric circuit, that is north of the calm zone, cirrus clouds, forming what is known as a "mackerel" sky, are almost invariably the precursors of bad weather, especially if the wind is from the west or south-west.

Generally speaking the appearance of cirrus clouds is accompanied by a falling barometer. When this phenomenon becomes accentuated, and the sky is covered with nimbus, rain falls in summer, snow in winter. At the eastern or southern edge of the calm zone, on the contrary, which is traversed by the descending portion of the circle, a falling glass does not indicate rain if cirrus is accompanied by north or north-easterly winds, but is a sign of

fine, dry weather. Here again barometric observations must be read in conjunction with the presence of cirrus, which furnishes the best evidence as to the direction of the wind at high altitudes.

The degree of clearness of the sky, and its colour at sunset, which depend upon the quantity of moisture in the atmosphere, are also excellent local signs, from which peasant and fisherman derive reliable information. By combining the observation of these various local symptoms with a careful study of the general charts, one may hope to forecast the weather fairly accurately twenty-four hours ahead; but to do more is still beyond our power.

*Types of Weather*.—In comparing various daily weather charts with each other, no two are ever found to be identical; but many are seen to approach closely to a given "type" in regard to the grouping of the isobars.

In making these comparisons, many charts are found to show a given type of weather, the similarity between them being due to a long series of observations extending over many years. Several recognised and recurrent types of weather have thus been classified, among which some appear more frequently than others on the synoptic charts; these are the stable types, always characterised by the settled, well-defined presence of an anticyclone.

It can easily be understood that the study of these "types of weather" can be of great interest; unfortunately these studies are not yet sufficiently advanced to enable us to draw more accurate conclusions from them, and these lessons must remain for the present elementary and general in scope. We have therefore merely drawn attention to these comparisons for the benefit of those readers who wish to undertake a more complete study of meteorology.

*Forecasts for Long Periods*.—As to the possibility of forecasting weather for long periods in the future, we have already said how little the science of meteorology is as yet in a position to perform this service. Many attempts have been made to establish various different "periods," some solar, some lunar, others corresponding to the

variations in the level of certain inland seas; but no really scientific results have been obtained from such speculations. The various outside influences to which the earth is subject are far too complex to enable us to deduce accurate information from their study.

In the actual condition of this science, any attempt to predict weather conditions with accuracy over long periods of time can only be illusory. Such attempts are quite unscientific, and are only to be regarded as efforts of the imagination.—(*From A. Berget's "Physique du Globe," chapter on "Prévisions météorologiques."*)

position of the spot in relation to the sides of the rectangle. Thus in the neighbourhood of Pau, for instance, which is indicated by a spot at the base of compartment 39 on the plan (Fig. 1), the guiding mark would appear as follows:

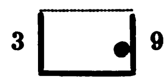



FIG. 2.

Aerial guide mark on the roofs of Pau, situated in the locality corresponding to the position of the black spot, on the half sheet and on the assembled plan. The co-ordinates of the S.W. angles of sheet 39 are: 313° polar distance and 179° east longitude from anti-Greenwich; or 43°N. latitude and 1° W. longitude from Greenwich.

Keeping his eyes on this small scale plan (Fig. 1), which would be easy to remember and on which the route from, say, Bourges to Pau had been marked before starting, the pilot could steer by the guide marks bearing the corresponding figures, without actually looking at the map itself; but a map would be necessary for landing.

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